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(71) Applicant: **Siemens Aktiengesellschaft**
80333 München (DE)

(72) Inventor: **Schindler, Tobias**
77871 Renchen-Ulm (DE)

(74) Representative: **Maier, Daniel Oliver**
Siemens AG
Postfach 22 16 34
80506 München (DE)

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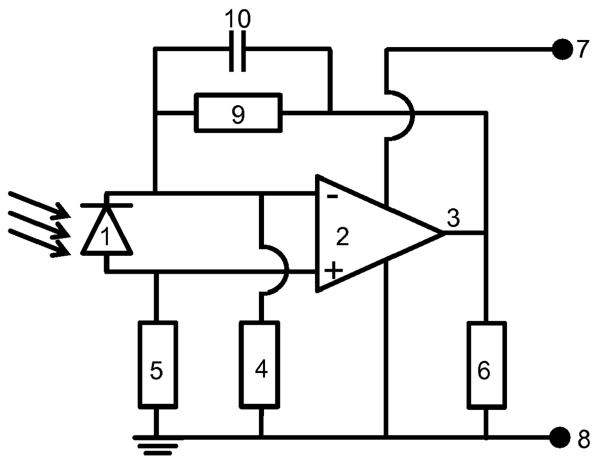
(54) **FLAME DETECTION FOR COMBUSTION APPLIANCES**

(57) Flame detection for combustion appliances. A sensor configuration comprising a sensor (1) with sensor terminals, the at least a sensor (1) being configured to produce a signal offset when receiving at least 1.1 Lux, and to produce equal signals when receiving less than 1.1 Lux, a differential amplifier (2) produces a current at its output channel (3) in response to the signal offset applied to its input channels, a load member (6) dissipates a first amount of power as a function of the current produced at the output channel (3), the differential amplifier (2) draws a first load current from the supply terminals (7, 8) in response to the signal offset applied by the sensor (1) to its input channels, the differential amplifier (2) draws a second quiescent current from the supply terminals (7, 8) in response to equal signals applied to its input channels (-, +).

FIG 1



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Description

Background

[0001] The instant disclosure generally relates to devices for flame detection in combustion appliances. More particularly, the instant disclosure relates to flame detection that is not based on CdS diodes.

[0002] Combustion appliances for fossil fuels such as gas burners generally rely on optical sensors that detect the presence of a flame. Signals obtained from these optical sensors are processed to ensure safe operation of the appliance.

[0003] Optical sensors suitable for flame detection need to meet a plethora of conflicting technical requirements. They need to exhibit low dark currents in order that false alarms are avoided. Suitable sensors also need be sensitive enough to detect low levels of incident light such as 0.5 Lux. In other words, the sensors and their detection circuits are required to minimize both false positives (type I errors) and false negatives (type II errors). The additional requirement of low-cost sensors further exacerbates the problem.

[0004] Due to low levels of dark currents, known sensors suitable for flame detection include cadmium sulfide (CdS) sensors. The use of such sensors in flame detection is widespread. Actually, CdS photoresistors are poised to be phased out due to RoHS (restrictions on hazardous substances) codes. With CdS elements being phased out, there is a need to find adequate replacements.

[0005] The Chinese patent CN101221071B issued on 6 October 2010 and teaches a flame detection device. CN101221071B discloses a circuit with a light-receiving element 11 and with a flame detector 20. The light-receiving element 11 comprises a Si photodiode and connects to the detector 20 via a cable 30. A filter circuit 13 and a dark current adder circuit 12 are arranged between the cable 30 and the light-receiving element 11. The filter circuit 13 functions to minimize adverse influences due to noise. In addition, a diode 14 inhibits faults due to polarity reversal.

[0006] The European patent EP0942232B1 issued on 21 September 2005. EP0942232B1 teaches a flame sensor with dynamic sensitivity adjustment. The disclosure of EP0942232B1 focuses on flame detection in gas turbines.

[0007] A circuit with two amplifiers U1A and U1B is employed to dynamically adjust sensitivity. A photo diode D4 made of silicon carbide (SiC) connects to the non-inverting input of amplifier U1A. The gain of amplifier U1A is controlled via a switch Q1. If the switch Q1 becomes conducting, it will shunt a resistor R4. Since R4 is part of the feedback loop that controls the gain of amplifier U1A, Q1 also controls the sensitivity of the circuit. The amplifier U1B in conjunction with a transistor Q2 acts to convert the output voltage of U1A into an electric current.

[0008] The circuit of EP0942232B1 employs a silicon carbide (SiC) diode that detects (ultraviolet) light at wavelengths such as 310 nm. EP0942232B1 employs a plurality of amplifiers U1A, U1B, and Q2 that are each susceptible to failure. The specification of EP0942232B1 teaches connection of the flame detection circuit via a single pair of wires W1, W2. The wires W1 and W2 supply the circuit with power and also carry the output signal of the circuit.

[0009] The patent application DE2654881A1 was filed on 3 December 1976 and was published on 21 September 1978. DE2654881A1 teaches a flame monitor with sensor head having a sensor in bridge circuit with non-linear characteristic and two voltage levels.

[0010] The present disclosure teaches a circuit for flame detection that dispenses with CdS technology. The instant disclosure focuses on a circuit for use in combustion appliances for fossil fuels.

Summary

[0011] The present disclosure provides a method and / or a device and / or a circuit for indicating the presence of a flame in a combustion appliance. To that end, an amplifier is employed that maintains (substantially) zero voltage drop over a photo diode. That is, the photoiode is not reverse biased and does not operate in photoconductive mode. The photodiode connects to the inverting input of the amplifier. The amplifier employed in the circuit described hereinafter exhibits a quiescent current that is lower than any allowable dark current.

[0012] Since the photo diode is not reverse biased, the dark current produced by the photo diode is minimized. Also, the use of an amplifier with low current supply mitigates the risk of false positives. In other words, an amplifier with a low current supply is employed to inhibit indication of a flame when there is no flame (type I errors).

[0013] The above objects are achieved by a method and / or by a device and / or by a system for control in accordance with the main claims of this disclosure. Preferred embodiments of the present disclosure are covered by the dependent claims.

[0014] It is an object of the present disclosure to provide a method and / or a device and / or a circuit that allows adjustment of sensitivity.

[0015] It is another object of the present disclosure to provide a method and / or a device and / or a circuit that allows connection via a two-wire connector.

[0016] It is a related object of the present disclosure to provide a method and / or a device and / or a circuit wherein a single pair of wires carries a supply signal and also a signal indicative of sensor output.

[0017] It is yet another object of the present disclosure to provide a method and / or a device and / or a circuit that is backward compatible with existing solutions.

[0018] It is a related object of the present disclosure to provide a method and / or a device and / or a circuit that can be plugged into a combustion appliance to replace existing sensors and / or sensor circuits.

[0019] It is still another object of the present disclosure to provide a method and / or a device and / or a circuit with minimum supply voltage.

[0020] It is still a related object of the present disclosure to provide a method and / or a device and / or a circuit for indicating the presence of a flame wherein the amplifier is an operational amplifier.

[0021] It is also an object of the present disclosure to provide a method and / or a device and / or a circuit with minimum zero point error.

[0022] It is also another object of the present disclosure to provide a method and / or a device and / or a circuit for indicating the presence of a flame wherein adverse influences due to (parasitic) leakage currents are inhibited.

[0023] It still is an object of the instant disclosure to provide a combustion appliance, in particular a combustion appliance for fossil fuels, with a device for flame detection and / or with a circuit for flame detection according to the instant disclosure.

Brief description of the drawings

[0024] Various features will become apparent to those skilled in the art from the following detailed description of the disclosed non-limiting embodiments. The drawings that accompany the detailed description can be briefly described as follows:

FIG 1 schematically depicts circuit diagram of a diode configuration according to the instant disclosure.

FIG 2 schematically depicts a diode configuration connected to a supply and detection circuit.

FIG 3 schematically depicts a diode configuration supplied by a bridge rectifier.

Detailed decription

[0025] FIG 1 shows a sensor configuration with a photodiode 1 and with a differential amplifier 2. Differential amplifier 2 provides inverting (-) and non-inverting (+) input channels. The two terminals of photodiode 1 (directly) connect to the inverting (-) and to the non-inverting (1+) input channels of differential amplifier 2. Photodiode 1 advantageously has its anode (directly) connected to the non-inverting input channel (+) of differential amplifier 2. The cathode of photodiode 1 advantageously (directly) connects to the inverting input channel (-) of differential amplifier 2.

[0026] In an embodiment, photodiode 1 is a silicon diode. It is desirable for purposes of flame detection that photodiode 1 exhibits a low value of parasitic parallel resistivity. A photocurrent produced by diode 1 may otherwise be consumed by the parasitic parallel resistivity of photodiode 1. Low values of parasitic parallel resistivity frequently indicate low values of dark current I_R.

[0027] It is also desirable to employ a photodiode with a small temperature coefficient. A small temperature coefficient makes the device and its circuit less sensitive to changes in temperature inside a combustion appliance. The temperature coefficient TC_I of the short-circuit current I_{SC} (at 25 degrees Celsius) is preferably less than 0.5%/Kelvin, even more preferred less than 0.3%/Kelvin, yet more preferred less than 0.1%/Kelvin or even 0.04%/Kelvin.

[0028] In addition, photodiode 1 ought to exhibit a spectral sensitivity $\lambda_{10\%}$ that matches and / or overlaps with the signal obtained from a flame in a combustion appliance. In an advantageous configuration, photodiode 1 exhibits a spectral sensitivity $\lambda_{10\%}$ between 200 nm and 900 nm, yet more preferred between 300 nm and 900 nm, even more preferred between 400 nm and 900 nm. Advantageously, photodiode 1 exhibits a spectral sensitivity at infrared wavelengths such as 900 nm that is less than 20%, preferably less than 10%, the sensitivity at 600 nm wavelength.

[0029] Photodiode 1 may, in a particular embodiment, be a type VEMD5510 device. According to an aspect, photodiode 1 is implemented as a surface-mounted device (SMD). Surface-mounted devices allow low cost manufacture at large scale. Surface-mounted device also allow miniaturized circuits. Photodiode 1 ideally withstands elevated temperatures inside a combustion appliance, in particular elevated temperatures inside or near a burner chamber of a combustion appliance.

[0030] Differential amplifier 2 amplifies the difference in signals between its inverting (-) and its non-inverting (+) input channels. Differential amplifier 2 provides an output channel 3 for the amplified signal. Differential amplifier 2 ideally is an operational amplifier. According to an aspect, amplifier 2 is implemented as a surface-mounted device (SMD). Surface-mounted devices allow low cost manufacture at large scale. Surface-mounted device also allow miniaturized circuits. According to another aspect, amplifier 2 comes as an integrated circuit (IC).

[0031] Differential amplifier 2 advantageously exhibits a low value of input bias current. A low value of input bias current of differential amplifier 2 yields benefits in terms of low photocurrents that can be detected. The input bias current of differential amplifier 2 (at 25 degrees Celsius) preferably is less than 100 pA, yet more preferred less than 20 pA, still more preferred less than 10 pA.

[0032] Differential amplifier 2 advantageously exhibits a low value of offset voltage. A low value of offset voltage 2 yields benefits in terms of low signals from diode 1 that can be detected. The offset voltage between the inverting and the non-inverting terminals of differential amplifier 2 (at 25 degrees Celsius) preferably is less than 50 mV, yet more preferred less than 20 mV, still more preferred less than 10 mV.

[0033] It is also desirable for amplifier 2 to draw small quiescent currents. It will otherwise be difficult to detect small changes in photocurrents by small changes (increases) in supply current. According to an aspect, the quiescent current of amplifier 2 at 25 degrees Celsius and at nominal supply voltage is less than 5 μA, preferably less than 2 μA, still more preferred 1.2 μA or less.

[0034] It is also crucial for amplifier 2 to function even with small supply voltages at its terminals 7 and 8. Small supply voltages ensure the circuit shown on FIG 1 can be plugged in the terminals for conventional CdS configurations. That is, the supply voltages of the differential amplifier 2 shown on FIG 2 should be in the same range as the supply voltages of conventional CdS configurations.

[0035] At 25 degrees Celsius, differential amplifier 2 preferably functions at supply voltages at its terminals 7 and 8 as small as $\pm$3 V. Differential amplifier yet more preferably functions at supply voltages as small as $\pm$2.5 V at 25 degrees Celsius. Still more preferably, amplifier 2 functions at supply voltages as low as $\pm$1.2 V or even $\pm$1.1 V at 25 degrees Celsius.

[0036] Photodiode 1 provides an anode terminal and a cathode terminal. The cathode terminal of photodiode 1 advantageously connects to the inverting input (-) channel of amplifier 2. The anode terminal of photodiode 1 advantageously connects to the non-inverting input (+) channel of amplifier 2.

[0037] Photodiode 1 provides an anode terminal and a cathode terminal. The cathode terminal of photodiode 1 advantageously connects to the inverting input (-) channel of amplifier 2. The anode terminal of photodiode 1 advantageously connects to the non-inverting input (+) channel of amplifier 2. When photodiode 1 is illuminated by a light source such as a flame, photodiode 1 will produce a photocurrent. The signal obtained from photodiode 1 will then be amplified by differential amplifier 2. Amplifier 2 will produce a signal at its output terminal 3 that is a function of the difference between the signals at its inverting (-) and non-inverting (+) input channels. In other words, amplifier 2 will produce a signal at its output terminal that is a function of the photocurrent produced by diode 1.

[0038] In an advantageous embodiment, amplifier 2 is a Texas Instruments® type LPV812 operational amplifier. Signals may also build up at the inverting (-) and / or at the non-inverting input (+) channels of amplifier 2 due to ambient influences. Those ambient influences are generally undesirable. The sensor configuration should inhibit such ambient influences in order to differentiate signals obtained from the photodiode and ambient noise.

[0039] The configuration of FIG 1 shows two impedances 4 and 5 that connect the input channels of amplifier 2 to earth. First impedance 4 connects the inverting input channel (-) of differential amplifier 2 to earth. Second impedance connects the non-inverting input channel (+) of differential amplifier 2 to earth.

[0040] In an embodiment, impedance 4 is a resistor (an ohmic resistor). Resistor 4 is chosen such that resistor 4 in conjunction with the input capacitance of amplifier 2 and / or in conjunction with a capacitor parallel to resistor 4 yields suitable RC time constants. The signal at the output channel 3 of amplifier 2 may otherwise be perturbed by remnant charges at the input channels of amplifier 2. In an embodiment, resistor 4 shows a resistivity of less than 100 kOhm (at 25 degrees Celsius), preferably less than 20 kOhm (at 25 degrees Celsius), yet more preferred less than 10 kOhm or even 4.7 kOhm (at 25 degrees Celsius).

[0041] Impedance 4 also maintains the cathode terminal of photodiode 1 (substantially) at earth potential. In other words, any reverse bias of photodiode 1 is inhibited. Photodiode 1 operates near zero voltage. Consequently, any issues due in relation to dark currents through photo diode 1 are mitigated.

[0042] Impedances 4 and 9 determine the output signal of amplifier 2 as a function of photocurrent. A photocurrent emanates from sensor 1 and flows through impedance 5 to ground. The potential at the non-inverting (+) input channel thus increases. Amplifier 2 then produces equal signals at the inverting (-) and non-inverting (+) input channels by driving an electric current through impedance 9 (and also through sensor 1). Consequently, the voltage drop over impedance 4 is the same as the voltage drop over impedance 5. The input offset voltage determines the precision of amplifier 2 and also the voltage bias of sensor 1.

[0043] According to an aspect, impedance 5 is a resistor (such as an ohmic resistor). Resistor 5 is chosen such that resistor 5 in conjunction with the input capacitance of amplifier 2 yields suitable RC time constants. The signal at the output channel 3 of amplifier 2 may otherwise be perturbed by remnant charges at the input channels of amplifier 2. Resistor 5 may, by way of non-limiting example, have a resistivity of 2.2 MOhm (at 25 degrees Celsius). Resistor 5 may, by way of another non-limiting example, have a resistivity of 4.7 MOhm (at 25 degrees Celsius). Resistor 5 may, by of yet another non-limiting example, have a resistivity of 6.8 MOhm or even 10 MOhm (at 25 degrees Celsius).

[0044] By choosing suitable impedances 4 and / or 5, the characteristics of the sensor configuration can be matched to actual values of photocurrent. Photocurrents may vary, by way of non-limiting example, due to light attenuation by a housing of the configuration and / or due to different sensors 1 used. Impedance 5 advantageously yields an increase in voltage at output channel 3 without requiring extra amplification. A higher level of amplification by amplifier 2 would otherwise be required. Higher levels of amplification do, however, adversely affect the offset voltage of amplifier 2. An augmented offset voltage would then exacerbate the inaccuracies and / or error signals of the configuration.

[0045] The skilled person understands that the characteristic of resistor 5 may to some extent also be capacitive. The skilled person also understands that a capacitive member may be connected in parallel to resistor 5. The capacitive member functions to create a well-defined capacitance between the terminals of resistor 5. The capacitive member thereby contributes to a well-defined RC time constant.

[0046] Impedance 6 connects the output channel 3 to earth. Photodiode 1 under the influence of incident light produces a photocurrent. The corresponding signal is amplified by differential amplifier 2. Differential amplifier 2 then produces a signal at its output channel that is a function of the photocurrent through diode 1. Consequently, impedance 6 dissipates an amount of (electric) power that is a function of the photocurrent through photodiode 1. Terminals V+ 7 and V- 8 of the circuit feed this amount of power to amplifier 2.

[0047] Impedance 6 is chosen such that the amount of power dissipated is within acceptable limits of differential amplifier 2. Impedance 6 is also chosen such that light incident on diode 1 results in a measurable increase in supply current through terminals 7, 8. Impedance 6 is preferably chosen such that 2 Lux of incident light yield a measureable increase in supply current. Impedance 6 is more preferably chosen such that 1 Lux of incident light yields a measureable increase in supply current. Impedance 6 is still more preferably chosen such that 1.1 Lux of incident light yields a measureable increase in supply current.

[0048] According to an aspect, a measurable increase in supply current (power) through terminals 7, 8 is at least five times the value of the quiescent current of amplifier 2. More preferred, a measurable increase in supply current (power) through terminals 7, 8 is at least twice the value of the quiescent current of amplifier 2. Still more preferred, a measurable increase in supply current (power) through terminals 7, 8 is at least half the value of the quiescent current of amplifier 2. In a particular embodiment, oversampling yields further improvements on the signal-to-noise ratio of the signal between terminals 7 and 8.

[0049] In an embodiment, impedance 6 is a resistor (such as an ohmic resistor). In a preferred embodiment, resistor 6 exhibits a resistivity at 25 degrees Celsius of 100 kOhm or 68 kOhm or 47 kOhm or 33 kOhm or 22 kOhm or 10 kOhm.

[0050] Terminals 7 and 8 are advantageously implemented as compatible with the terminals of existing CdS based configurations. Terminals 7 and 8 preferably provide suitable plugs and / or suitable sockets that allow terminals 7 and 8 to be readily connected to (the terminals of) an existing combustion appliance.

[0051] A feedback loop with feedback members 9, 10 connects the output channel 3 of amplifier 2 to its inverting input channel (-). Feedback member 9 preferably is a resistor (such as an ohmic resistor). Feedback member 10 preferably is a capacitor.

[0052] The signal U_{out} at the output channel 3 of amplifier 2 is a function of the resistivity $R_{feedback}$ of member 9:

$$U_{\text{out}} = f(R_{\text{feedback}})$$

Ideally, U_{out} is a first order polynomial of the resistivity $R_{feedback}$. U_{out} is also function of the product $R_{feedback} \cdot I_{ph}$ of the resistivity $R_{feedback}$ of member 9 and of the current I_{ph} through photodiode 1:

$$U_{\text{out}} = f\left(R_{\text{feedback}} \cdot I_{\text{ph}}\right)$$

Ideally, U_{out} is a first order polynomial of the product $R_{feedback} \cdot I_{ph}$.

[0053] In an embodiment, U_{out} also depends on the values *R4* and *R5* chosen for impedances 4 and 5:

$$U_{\text{out}} = \left(R5 + R_{\text{feedback}} \cdot \frac{R5}{R4} + R_{\text{feedback}}\right) \cdot I_{\text{ph}}$$

[0054] Since the photocurrent I_{ph} at small levels of incident light attains small values, large values of $R_{feedback}$ are required to produce significant changes in output voltage U_{out}.

[0055] Suitable values of the resistivity of member 9 mitigate adverse influences due to offset voltages and / or bias currents etc. The resistivity of member 9 may, by way of non-limiting example, attain 0.47 MOhm at 25 degrees Celsius.

The resistivity of member 9 may, by way of another non-limiting example, attain 2 MOhm at 25 degrees Celsius. The resistivity of member 9 may, by way of yet another non-limiting example, be 1 MOhm at 25 degrees Celsius. It is also envisaged that member 9 is a potentiometer. That way, the sensitivity of the circuit shown on FIG 1 can be tuned.

[0056] Feedback member 10 advantageously is a capacitor. Capacitor 10 is connected in parallel to resistor 9. Capacitor 10 contributes to optimizing the dynamic characteristics of the system and / or inhibits instability (of differential amplifier 2). The choice of capacitor 10 depends on the input capacitance of amplifier 2. The capacitance of member 10 also depends on the resistivity of the feedback resistor 9. In addition, the choice of capacitance 10 is influenced by the capacitance of photodiode 1. In an exemplary embodiment, the capacitor 100 nF or a 20 nF or a 100 pF or a 20 pF capacitor.

[0057] The skilled person understands that the characteristic of resistor 9 may to some extent also be capacitive. According to a particular embodiment, the feedback members 9 and 10 are implemented as a single resistive-capacitive member. It is also envisaged that another particular embodiment dispenses with capacitor 10.

[0058] It is also envisaged to dispense with the feedback loop between the output channel 3 and the non-inverting input channel of amplifier 2. In this particular embodiment, amplifier 2 effectively becomes a comparator. Accordingly, amplifier 2 produces a high output signal (such as 3 V, 2.5 V, 1.2 V or 1.1 V) indicative of a photocurrent through diode 1. Amplifier 2 produces a low output signal (substantially 0 V) when there is no photocurrent through diode 1. The embodiment advantageously employs a positive feedback loop between the output channel 3 of amplifier 2 and its non-inverting (-) input channel. The embodiment ideally relies on a sensor 1 that exhibits (substantially) linear characteristics in the relevant operational range.

[0059] Now referring to FIG 2, a connection is displayed between the sensor configuration and a supply and detection circuit 11. The supply and detection circuit 11 functions to supply the sensor configuration with electric current and / or with electric power. The supply and detection circuit 11 also functions to detect any changes in current and / or in power to the sensor configuration due to the photodiode 1 receiving light.

[0060] The sensor configuration provides a pair of wires 12, 13 and a connector 14. It is envisaged that connector 14 plugs into a suitable connector of supply and detection circuit 11. Connector 14 thereby establishes an electric connection between the wires 12, 13 and the supply and detection circuit 11. Wires 12, 13 ideally directly connect to supply terminals 7, 8.

[0061] The sensor configuration according to the instant disclosure is advantageously arranged on a (printed) circuit board. The skilled person separates the paths for supply voltages 7, 8 and / or for inverting and / or non-inverting input channels and / or for output channels 3 in order that parasitic currents are inhibited. It is envisaged that suitable guard traces are arranged on the (printed) circuit board between these paths, since guard traces further reduce parasitic effects.

[0062] It is envisaged that connector 14 also comprises an ampere meter, an analog-to-digital converter, a processing module, and / or a radio frequency module connected to an antenna. Ideally, connector 14 also comprises a power source such as an electric battery and / or an energy harvesting circuit to supply relevant components with power. The ampere meter is arranged in series with any of the wires 12, 13 and records a current value indicative of the current through any of the wires 12, 13. The analog-to-digital converter receives the analog current value from the ampere meter and converts the value into a digital representation. The processing unit generates a message for transmission over a computer network from the digital representation. The digital message is then sent to the radio frequency module. The radio frequency module converts the message to a radio frequency signal which is forwarded to the antenna. In an embodiment, the analog-to-digital converter and / or the radio frequency module is integrated in the processing module. It is envisaged to split the message in a plurality of messages. The latter step offers benefits in terms of redundancy and / or immunity to disturbances.

[0063] The radio frequency module may allow for unidirectional or for bidirectional wireless communication. Data transmission may be directional or non-directional. According to an aspect, radio frequency module employs a modulation process that accommodates for the characteristics of the air interface between the receiver and the transmitter. Factors that influence the choice of any particular modulation process include, but are not limited to, range, immunity to disturbances, bit rate, channel bandwidth, characteristics of the channel etc.

[0064] According to an aspect, the modulation process may change over time as a function of the characteristics of the communication channel. The modulation process thus adapts continuously in order to achieve optimum performance.

[0065] According to another aspect, the bandwidth of any particular channel is subdivided into a plurality of frequency bands. Ideally, each frequency band uses its own particular modulation process that suits the characteristics of the frequency band. Each frequency band advantageously carries a proportion of data traffic that depends on the capacity of the frequency band for data transmission.

[0066] According to yet another aspect, a digital modulation process is employed to reduce and / or to mitigate disturbances. A digital modulation process uses a digital signal to modulate an analog carrier. Digital modulation processes may, by way of non-limiting example, rely on techniques such as phase-shift-keying, continuous phase modulation, and / or quadrature amplitude modulation.

[0067] Now referring to FIG 3, a bridge rectifier 15 is shown that supplies currents at its load terminals 18, 19 to the diode configuration. The bridge rectifier 15 has its load terminals 18, 19 connected to the terminals 7, 8 of the diode configuration. The bridge rectifier 15 also provides a pair of supply terminals 16, 17. Those supply terminals ideally connect to a pair of wires 12, 13 that supplies the entire configuration with power. The arrangement of FIG 3 offers benefits in terms of immunity to polarity reversal and / or to wiring errors. The sensor configuration is not going to be damaged, even if the voltage between wires 12, 13 is erroneously reversed.

[0068] According to an aspect, electric components of the circuits disclosed herein such as resistors, capacitors, and guard traces are arranged on a circuit board via an additive manufacturing technique. These resistors and capacitors can, in particular, be arranged via a three-dimensional additive manufacturing technique. The skilled person selects suitable materials as well as suitable parameters such as temperature when printing electric components. In addition, necessary mechanical members such as sockets for integrated circuits, in particular sockets for operational amplifiers, can be arranged via additive manufacturing. The skilled person selects suitable materials as well as suitable parameters such as stiffness and / or glass-transition temperature when printing mechanical members. Additive manufacturing techniques offer benefits in terms of low cost even at small quantities.

[0069] In other words, the instant disclosure teaches a sensor configuration for a combustion appliance comprising:

at least a sensor 1 with a first and a second sensor terminal, the at least a sensor 1 being configured to produce a signal offset, preferably a pre-defined signal offset, between its terminals in response to receiving a first amount of light of at least 1.1 Lux, and to produce (substantially) equal signals at its terminals in response to receiving a second amount of light of less than 1.1 Lux (preferably less than 0.9 Lux, yet more preferred less than 0.5 Lux), in particular when receiving a second amount of light of less than 1.1 Lux, in yet another embodiment when receiving an amount of light of less than 0.5 Lux (even more preferred less than 0.3 Lux),
at least a differential amplifier 2 comprising a first 7 and a second 8 supply terminal, an output channel 3, an inverting - and a non-inverting + input channel,
at least a load member 6 connecting the output channel 3 to one of the supply terminals 7, 8,
wherein the first sensor terminal (directly) connects to the inverting input channel - and the second sensor terminal (directly) connects to the non-inverting input channel +, such that the at least a sensor 1 is configured to apply signals at the input channels -, + (of the differential amplifier 2), the at least a differential amplifier 2 being configured to produce a current at its output channel 3 in response to the signal offset applied by the at least a sensor 1 between the inverting - and the non-inverting + input channels, and the at least a load member 6 being configured to dissipate a first amount of power as a function of the current produced at the output channel 3,
the at least a differential amplifier 2 being configured to draw a first load current from the supply terminals 7, 8 in response to the signal offset applied by the at least a sensor 1 between the inverting - and the non-inverting + input channels,
the at least a differential amplifier 2 being configured to draw a second quiescent current from the supply terminals 7, 8 in response to substantially equal signals applied by the at least a sensor 1 at the input channels -, +,
wherein the first load current exceeds the second quiescent current by at least fifty percent, in a particular embodiment exceeds the second quiescent current by at least twenty percent, in more particular embodiment exceeds the second quiescent current by at least ten percent, and the second quiescent current is less than five hundred microAmperes, in particular the second quiescent current is less than seventy microAmperes, in an embodiment the second quiescent current is less than fifteen microAmperes.

[0070] Advantageously, the first sensor terminal directly connects to the inverting input channel (-). The second sensor terminal advantageously directly connects to the non-inverting input channel (+).

[0071] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the at least a differential amplifier 2 is configured to draw a first load current from the supply terminals 7, 8 in response to the at least a load member 6 dissipating the first amount of power.

[0072] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the at least a differential amplifier 2 is configured to maintain a voltage drop of (substantially) between its inverting - and its non-inverting input channels.

[0073] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the at least a differential amplifier 2 is configured to maintain a voltage drop of (substantially) between its inverting - and its non-inverting input channels, such that reverse bias of the sensor 1 (by the at least an amplifier 2) is inhibited.

[0074] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the at least a differential amplifier 2 is configured to maintain a voltage drop of (substantially) between its inverting - and its non-inverting input channels, such that reverse bias of the sensor 1 (by the at least an amplifier 2) is inhibited and any dark current of sensor 1 is minimized and / or eliminated.

[0075] The instant disclosure also teaches one of the aforementioned sensor configurations, the sensor configuration additionally comprising at least a feedback resistor 9 such as an ohmic feedback resistor 9 connecting the output channel 3 to the inverting - input channel of the at least a differential amplifier 2.

[0076] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the at least a feedback resistor 9 comprises a potentiometer.

[0077] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the at least a feedback resistor 9 comprises a potentiometer, such that the resistance of the at least a feedback resistor 9 can be tuned.

[0078] The instant disclosure also teaches one of the aforementioned sensor configurations, the sensor configuration additionally comprising at least a feedback network 9 connecting the output channel 3 to the inverting - input channel of the at least a differential amplifier 2,
wherein the feedback network 9 comprises a plurality of resistors and at least a switch,
wherein the feedback network 9 exhibits a resistivity,
wherein the switch is configured to change the resistivity of the feedback network 9 (by actuating the switch).

[0079] The instant disclosure also teaches one of the aforementioned sensor configurations, the sensor configuration additionally comprising at least a feedback capacitor 10 connecting the output channel 3 to the inverting - input channel of the at least a differential amplifier 2.

[0080] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the at least a sensor 1 has a sensor capacitance indicative of a capacitance of the at least a sensor 1,
wherein the at least a feedback capacitor 10 has a feedback capacitance indicative of a capacitance of the at least a feedback capacitor 10,
wherein the feedback capacitance in conjunction with the sensor capacitance is configured to inhibit instability of the at least a differential amplifier 2.

[0081] The instant disclosure also teaches one of the aforementioned sensor configurations, the sensor configuration additionally comprising at least a first earth impedance 4 such as an (ohmic) earth resistor connecting the inverting - input channel to one of the supply terminals 7, 8.

[0082] The instant disclosure also teaches one of the aforementioned sensor configurations, the sensor configuration additionally comprising at least a second earth impedance 5 such as an (ohmic) earth resistor connecting the non-inverting + input channel to one of the supply terminals 7, 8,
wherein the at least a first earth impedance 4 and the at least a second earth impedance 5 (an in an embodiment also the at least a load impedance 6) all connect to the same supply terminal 7, 8.

[0083] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the at least a first earth impedance 4 has a first impedance value indicative of an impedance of the at least a first earth impedance 4, and the at least a second earth impedance 5 has a second impedance value indicative of an impedance of the at least a second earth impedance 5,
wherein the second impedance value exceeds the first impedance value at least by a factor ten, preferably at least by a factor one hundred, more preferably at least by a factor one thousand.

[0084] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the sensor configuration provides a pair of wires with a first wire 12 and with a second wire 13,
wherein the first load current is an electric current, wherein the second quiescent current is an electric current, wherein the first wire 12 connects to the first supply terminal 7 and the second wire 13 connects to the second supply terminal 8, wherein the pair of wires is configured to exclusively supply the sensor configuration with electric currents and / or with electric signals.

[0085] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the pair of wires (at its far end) provides a connector 14 for connection of the first wire 12 and of the second wire 13 to a supply and detection circuit 11,
wherein the connector 14 is the only connector of the sensor configuration configured to connect the first wire 12 and the second wire 13 to the supply and detection circuit 11.

[0086] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the pair of wires (at its far end) provides a connector 14 for connection of the first wire 12 and of the second wire 13 to a supply and detection circuit 11,
wherein the connector 14 is the only connector of the sensor configuration configured to connect the sensor configuration to the supply and detection circuit 11.

[0087] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the at least a sensor 1 comprises and / or is a photodiode.

[0088] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the first sensor terminal connects to the cathode of the photodiode and / or the second sensor terminal connects to the anode of the photodiode.

[0089] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the photodiode has a temperature coefficient indicative of a dependence of a short-circuit current of the photodiode on temperature,
wherein the temperature coefficient at three hundred degrees Kelvin is less than one percent per Kelvin, preferably less than half a percent per Kelvin, more preferred less than 0.2 percent per Kelvin, or even 0.04 percent per Kelvin or less.

[0090] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the photodiode 1 has a first spectral sensitivity at 900 nm optical wavelength and a second spectral sensitivity at 600 nm optical wavelength,
the second spectral sensitivity is at least five times, preferably at least ten times, the first spectral sensitivity.

[0091] The aforementioned optical wavelengths relate to wavelengths of light incident on photodiode 1, preferably from a combustion appliance. The aforementioned values of sensitivity offer benefits in terms of optimum match with typical wavelengths of flames combustion appliances.

[0092] The instant disclosure also teaches one of the aforementioned sensor configurations, wherein at least a differential amplifier 2 is an operational amplifier, in particular a low-noise operational amplifier and / or an ultra low-noise operational amplifier and / or an instrument amplifier.

[0093] The instant disclosure also teaches a combustion appliance with a sensor configuration according to the instant disclosure.
The instant disclosure also teaches one of the aforementioned sensor configurations, wherein the sensor configuration additionally comprises a bridge rectifier 15 with supply terminals 16, 17 and with load terminals 18, 19, and a pair of wires with a first wire 12 and with a second wire 13,
wherein the first load current is an electric current,
wherein the second quiescent current is an electric current,
wherein the first wire 12 and the second wire 13 connect to the supply terminals 16, 17 of the bridge rectifier 15,
wherein the bridge rectifier 15 is configured to convert an alternating electric current applied between its supply terminals 16, 17 into a direct electric current between its load terminals 18, 19,
wherein the first supply terminal 7 and the second supply terminal 8 connect to the load terminals 18, 19 of the bridge rectifier 15,
wherein the pair of wires is configured to exclusively supply the sensor configuration with electric currents and / or with electric signals.

[0094] Any steps of a method according to the present application may be embodied in hardware, in a software module executed by a processor, in a cloud computing arrangement, or in a combination thereof. The software may include a firmware, a hardware driver run in the operating system, or an application program. Thus, the invention also relates to a computer program product for performing the operations presented herein. If implemented in software, the functions described may be stored as one or more instructions on a computer-readable medium. Some examples of storage media that may be used include random access memory (RAM), read only memory (ROM), flash memory, EPROM memory, EEPROM memory, registers, a hard disk, a removable disk, other optical disks, or any available media that can be accessed by a computer or any other IT equipment and appliance.

[0095] It should be understood that the foregoing relates only to certain embodiments of the invention and that numerous changes may be made therein without departing the scope of the invention as defined by the following claims. It should also be understood that the invention is not restricted to the illustrated embodiments and that various modifications can be made within the scope of the following claims.

Reference numerals

[0096]

1 photodiode
2 differential amplifier
3 output channel
4 impedance
5 impedance
6 dissipation member
7 (V+) terminal
8 (V-) terminal
9 feedback member
10 feedback member
11 supply and detection circuit
12 wire
13 wire
14 connector
15 bridge rectifier
16 supply terminal
17 supply terminal

18 load terminal
19 load terminal

Claims

1. A sensor configuration for a combustion appliance comprising:

at least a sensor (1) with a first and a second sensor terminal, the at least a sensor (1) being configured to produce a signal offset between its terminals in response to receiving a first amount of light of at least 1.1 Lux, and to produce equal signals at its terminals in response to receiving a second amount of light of less than 1.1 Lux,
at least a differential amplifier (2) comprising a first (7) and a second (8) supply terminal, an output channel (3), an inverting (-) and a non-inverting (+) input channel,
at least a load member (6) connecting the output channel (3) to one of the supply terminals (7, 8),
wherein the first sensor terminal connects to the inverting input channel (-) and the second sensor terminal connects to the non-inverting input channel (+), such that the at least a sensor (1) is configured to apply signals at the input channels (-, +),
the at least a differential amplifier (2) being configured to produce a current at its output channel (3) in response to the signal offset applied by the at least a sensor (1) between the inverting (-) and the non-inverting (+) input channels, and the at least a load member (6) being configured to dissipate a first amount of power as a function of the current produced at the output channel (3),
the at least a differential amplifier (2) being configured to draw a first load current from the supply terminals (7, 8) in response to the signal offset applied by the at least a sensor (1) between the inverting (-) and the non-inverting (+) input channels,
the at least a differential amplifier (2) being configured to draw a second quiescent current from the supply terminals (7, 8) in response to equal signals applied by the at least a sensor (1) at the input channels (-, +),
wherein the first load current exceeds the second quiescent current by at least fifty percent, and the second quiescent current is less than fifteen microamperes,
characterized in that
the first sensor terminal directly connects to the inverting input channel (-) and the second sensor terminal directly connects to the non-inverting input channel (+).

2. The sensor configuration according to claim 1, the sensor configuration additionally comprising at least a feedback resistor (9) connecting the output channel (3) to the inverting (-) input channel of the at least a differential amplifier (2).

3. The sensor configuration according to any of the claims 1 or 2, the sensor configuration additionally comprising at least a feedback capacitor (10) connecting the output channel (3) to the inverting (-) input channel of the at least a differential amplifier (2).

4. The sensor configuration according to claim 3, wherein the at least a sensor (1) has a sensor capacitance indicative of a capacitance of the at least a sensor (1),

wherein the at least a feedback capacitor (10) has a feedback capacitance indicative of a capacitance of the at least a feedback capacitor (10),
wherein the feedback capacitance in conjunction with the sensor capacitance is configured to inhibit instability of the at least a differential amplifier (2).

5. The sensor configuration according to any of the claims 1 to 4, the sensor configuration additionally comprising at least a first earth impedance (4) connecting the inverting (-) input channel to one of the supply terminals (7, 8).

6. The sensor configuration according to claim 5, the sensor configuration additionally comprising at least a second earth impedance (5) connecting the non-inverting (+) input channel to one of the supply terminals (7, 8),

wherein the at least a first earth impedance (4) and the at least a second earth impedance (5) both connect to the same supply terminal (7, 8).

7. The sensor configuration according to claim 6, wherein the at least a first earth impedance (4) has a first impedance value indicative of an impedance of the at least a first earth impedance (4), and the at least a second earth impedance

(5) has a second impedance value indicative of an impedance of the at least a second earth impedance (5),

wherein the second impedance value exceeds the first impedance value at least by a factor ten.

8. The sensor configuration according to any of the claims 1 to 7, wherein the sensor configuration provides a pair of wires with a first wire (12) and with a second wire (13),

wherein the first load current is an electric current,
wherein the second quiescent current is an electric current,
wherein the first wire (12) connects to the first supply terminal (7) and the second wire (13) connects to the second supply terminal (8),
wherein the pair of wires is configured to exclusively supply the sensor configuration with electric currents and / or with electric signals.

9. The sensor configuration according to claim 8, wherein the pair of wires provides a connector (14) for connection of the first wire (12) and of the second wire (13) to a supply and detection circuit (11),

wherein the connector (14) is the only connector of the sensor configuration configured to connect the first wire (12) and the second wire (13) to the supply and detection circuit (11).

10. The sensor configuration according to claim 8 or 9, wherein the pair of wires provides a connector (14) for connection of the first wire (12) and of the second wire (13) to a supply and detection circuit (11),
wherein the connector (14) is the only connector of the sensor configuration configured to connect the sensor configuration to the supply and detection circuit (11).

11. The sensor configuration according to any of the claims 1 to 9, wherein the at least a sensor (1) comprises a photodiode.

12. The sensor configuration according to claim 11, wherein the first sensor terminal connects to the cathode of the photodiode and the second sensor terminal connects to the anode of the photodiode.

13. The sensor configuration according to any of the claims 11 or 12, wherein the photodiode has a first spectral sensitivity at 900 nm optical wavelength and a second spectral sensitivity at 600 nm optical wavelength,
the second spectral sensitivity is at least five times the first spectral sensitivity.

14. The sensor configuration according to any of the claims 1 to 13, wherein at least a differential amplifier (2) is an operational amplifier.

15. The sensor configuration according to any of the claims 1 to 7, wherein the sensor configuration additionally comprises a bridge rectifier (15) with supply terminals (16, 17) and with load terminals (18, 19), and a pair of wires with a first wire (12) and with a second wire (13),
wherein the first load current is an electric current, wherein the second quiescent current is an electric current,
wherein the first wire (12) and the second wire (13) connect to the supply terminals (16, 17) of the bridge rectifier (15),
wherein the bridge rectifier (15) is configured to convert an alternating electric current applied between its supply terminals (16, 17) into a direct electric current between its load terminals (18, 19),
wherein the first supply terminal (7) and the second supply terminal (8) connect to the load terminals (18, 19) of the bridge rectifier (15),
wherein the pair of wires is configured to exclusively supply the sensor configuration with electric currents and / or with electric signals.

Amended claims in accordance with Rule 137(2) EPC.

1. A sensor configuration for a combustion appliance comprising:

a sensor (1) with a first and a second sensor terminal, the sensor (1) being configured to produce a signal offset between its terminals in response to receiving a first amount of light of at least 1.1 Lux, and to produce equal signals at its terminals in response to receiving a second amount of light of less than 1.1 Lux,

a differential amplifier (2) comprising a first (7) and a second (8) supply terminal, an output channel (3), an inverting (-) and a non-inverting (+) input channel,
a load member (6) connecting the output channel (3) to one of the supply terminals (7, 8),
wherein the first sensor terminal connects to the inverting input channel (-) and the second sensor terminal connects to the non-inverting input channel (+), such that the sensor (1) is configured to apply signals at the input channels (-, +),
the differential amplifier (2) being configured to produce a current at its output channel (3) in response to the signal offset applied by the sensor (1) between the inverting (-) and the non-inverting (+) input channels, and the load member (6) being configured to dissipate a first amount of power as a function of the current produced at the output channel (3),
the differential amplifier (2) being configured to draw a first load current from the supply terminals (7, 8) in response to the signal offset applied by the sensor (1) between the inverting (-) and the non-inverting (+) input channels,
the differential amplifier (2) being configured to draw a second quiescent current from the supply terminals (7, 8) in response to equal signals applied by the sensor (1) at the input channels (-, +),
wherein the first load current exceeds the second quiescent current by at least fifty percent, and the second quiescent current is less than fifteen microamperes,
characterized in that
the first sensor terminal directly connects to the inverting input channel (-) and the second sensor terminal directly connects to the non-inverting input channel (+).

2. The sensor configuration according to claim 1, the sensor configuration additionally comprising a feedback resistor (9) connecting the output channel (3) to the inverting (-) input channel of the differential amplifier (2).

3. The sensor configuration according to any of the claims 1 or 2, the sensor configuration additionally comprising a feedback capacitor (10) connecting the output channel (3) to the inverting (-) input channel of the differential amplifier (2).

4. The sensor configuration according to claim 3, wherein the sensor (1) has a sensor capacitance indicative of a capacitance of the sensor (1),

wherein the feedback capacitor (10) has a feedback capacitance indicative of a capacitance of the feedback capacitor (10),
wherein the feedback capacitance in conjunction with the sensor capacitance is configured to inhibit instability of the differential amplifier (2).

5. The sensor configuration according to any of the claims 1 to 4, the sensor configuration additionally comprising a first earth impedance (4) connecting the inverting (-) input channel to one of the supply terminals (7, 8) .

6. The sensor configuration according to claim 5, the sensor configuration additionally comprising a second earth impedance (5) connecting the non-inverting (+) input channel to one of the supply terminals (7, 8),
wherein the first earth impedance (4) and the second earth impedance (5) both connect to the same supply terminal (7, 8).

7. The sensor configuration according to claim 6, wherein the first earth impedance (4) has a first impedance value indicative of an impedance of the first earth impedance (4), and the second earth impedance (5) has a second impedance value indicative of an impedance of the second earth impedance (5),
wherein the second impedance value exceeds the first impedance value at least by a factor ten.

8. The sensor configuration according to any of the claims 1 to 7, wherein the sensor configuration provides a pair of wires with a first wire (12) and with a second wire (13),

wherein the first load current is an electric current,
wherein the second quiescent current is an electric current,
wherein the first wire (12) connects to the first supply terminal (7) and the second wire (13) connects to the second supply terminal (8),
wherein the pair of wires is configured to exclusively supply the sensor configuration with electric currents and / or with electric signals.

9. The sensor configuration according to claim 8, wherein the pair of wires provides a connector (14) for connection of the first wire (12) and of the second wire (13) to a supply and detection circuit (11),
wherein the connector (14) is the only connector of the sensor configuration configured to connect the first wire (12) and the second wire (13) to the supply and detection circuit (11).

10. The sensor configuration according to claim 8 or 9, wherein the pair of wires provides a connector (14) for connection of the first wire (12) and of the second wire (13) to a supply and detection circuit (11),
wherein the connector (14) is the only connector of the sensor configuration configured to connect the sensor configuration to the supply and detection circuit (11).

11. The sensor configuration according to any of the claims 1 to 9, wherein the sensor (1) comprises a photodiode.

12. The sensor configuration according to claim 11, wherein the first sensor terminal connects to the cathode of the photodiode and the second sensor terminal connects to the anode of the photodiode.

13. The sensor configuration according to any of the claims 11 or 12,
wherein the photodiode has a first spectral sensitivity at 900 nm optical wavelength and a second spectral sensitivity at 600 nm optical wavelength,
the second spectral sensitivity is at least five times the first spectral sensitivity.

14. The sensor configuration according to any of the claims 1 to 13,
wherein the differential amplifier (2) is an operational amplifier.

15. The sensor configuration according to any of the claims 1 to 7, wherein the sensor configuration additionally comprises a bridge rectifier (15) with supply terminals (16, 17) and with load terminals (18, 19), and a pair of wires with a first wire (12) and with a second wire (13),

wherein the first load current is an electric current,
wherein the second quiescent current is an electric current,
wherein the first wire (12) and the second wire (13) connect to the supply terminals (16, 17) of the bridge rectifier (15),
wherein the bridge rectifier (15) is configured to convert an alternating electric current applied between its supply terminals (16, 17) into a direct electric current between its load terminals (18, 19),
wherein the first supply terminal (7) and the second supply terminal (8) connect to the load terminals (18, 19) of the bridge rectifier (15),
wherein the pair of wires is configured to exclusively supply the sensor configuration with electric currents and / or with electric signals.

FIG 1

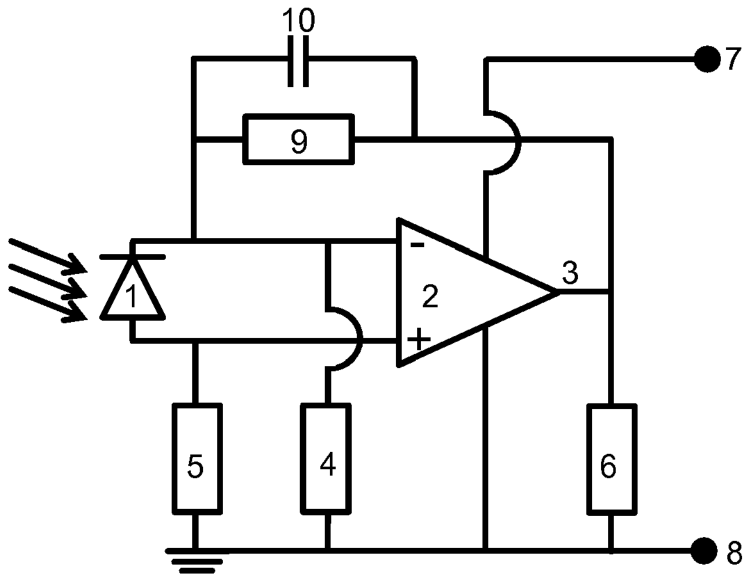


FIG 2

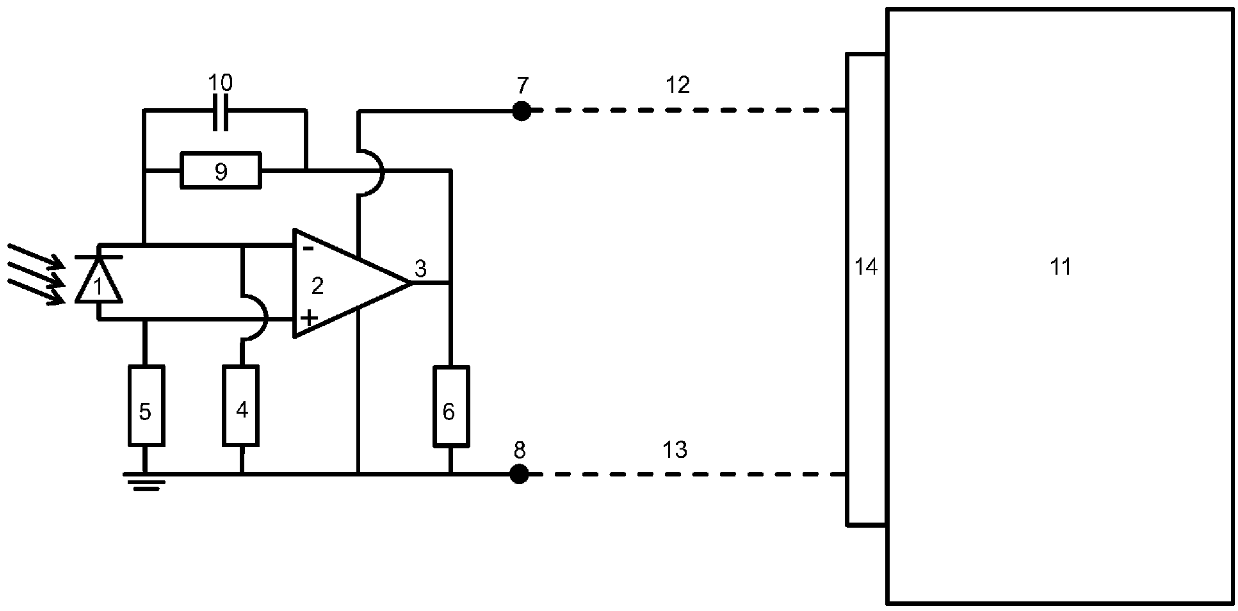
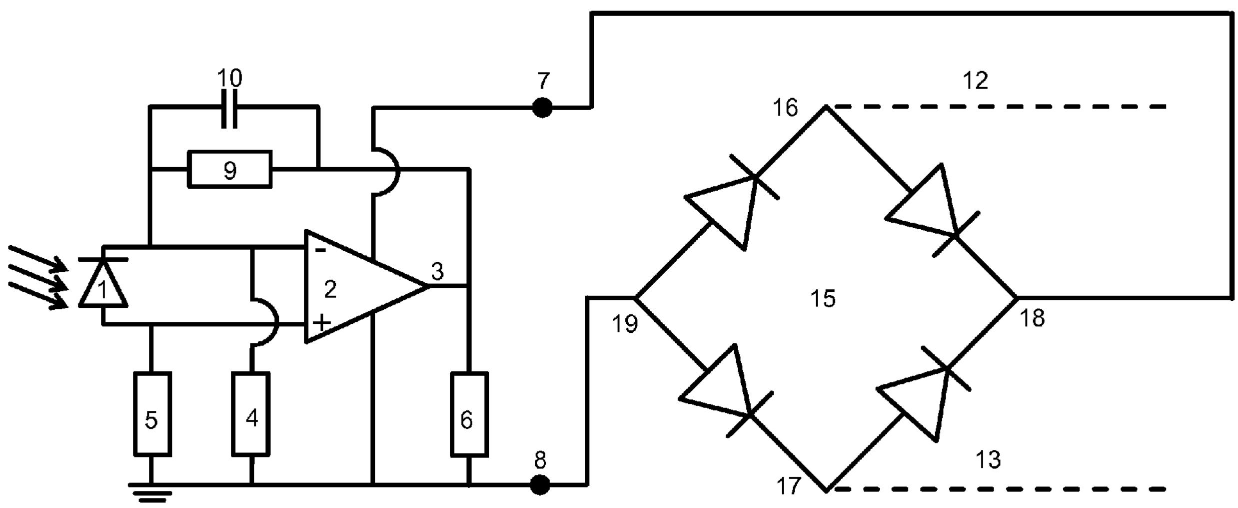


FIG 3



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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 2230

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	DE 26 54 881 A1 (LANDIS & GYR AG) 21 September 1978 (1978-09-21) * page 1, lines 1,2; figure 1 * * page 1, line 7 - line 15 * * page 4, line 28 - page 5, line 26 * -----	1-15	INV. F23N5/08
A	US 4 491 142 A (SHIMIZU KUNIO [JP]) 1 January 1985 (1985-01-01) * column 1, line 40 - line 44; figure 2a * * column 3, line 66 - column 4, line 15 * * column 4, line 37 - column 5, line 10 * -----	1	
A	US 6 652 266 B1 (MURGU CRISTIAN [CA] ET AL) 25 November 2003 (2003-11-25) * the whole document * -----	1-15	
A,D	EP 0 942 232 B1 (GEN ELECTRIC [US]) 21 September 2005 (2005-09-21) * the whole document * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

F23N

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	10 April 2018	Hauck, Gunther

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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....
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10-04-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 2654881 A1	21-09-1978	CH 606915 A5	15-11-1978
		DE 2654881 A1	21-09-1978
US 4491142 A	01-01-1985	DE 3234532 A1	15-12-1983
		FR 2528545 A1	16-12-1983
		GB 2122397 A	11-01-1984
		IT 1155927 B	28-01-1987
		JP S58219325 A	20-12-1983
		US 4491142 A	01-01-1985
US 6652266 B1	25-11-2003	AU 6197401 A	03-12-2001
		CA 2380441 A1	29-11-2001
		US 6652266 B1	25-11-2003
		WO 0190651 A1	29-11-2001
EP 0942232 B1	21-09-2005	DE 69927311 D1	27-10-2005
		DE 69927311 T2	22-06-2006
		EP 0942232 A2	15-09-1999
		JP 3270745 B2	02-04-2002
		JP H11316175 A	16-11-1999
		US 6013919 A	11-01-2000

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 101221071 B **[0005]**
- EP 0942232 B1 **[0006] [0008]**
- DE 2654881 A1 **[0009]**