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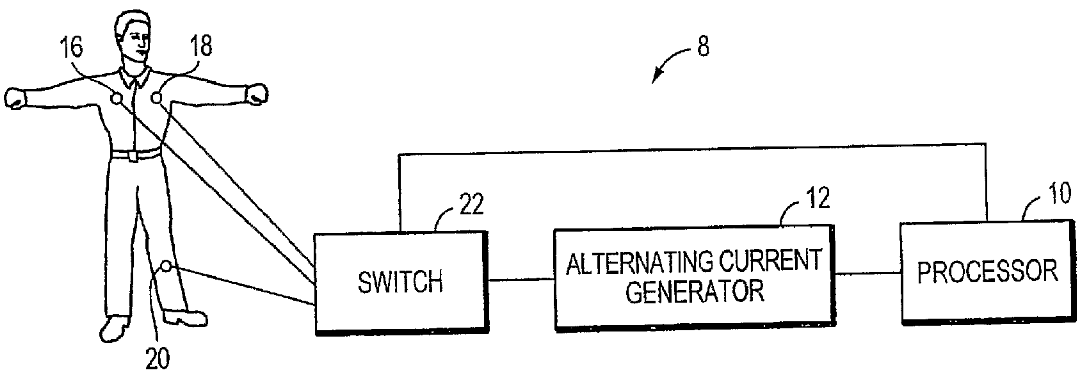
(54) **Title:** AUTOMATED ECG LEAD IMPEDANCE MEASUREMENT INTEGRATED INTO ECG GATING CIRCUITRY



(57) **Abstract:** The present invention relates to a system and method for determining the impedance of an electrode at the electrode-body interface. The electrode-body impedance of one of the electrodes may be calculated using the voltage difference between that electrode and a plurality of other electrodes, and the voltage and impedance of an alternating current generator in communication with the electrodes.

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AUTOMATED ECG LEAD IMPEDANCE MEASUREMENT INTEGRATED INTO ECG GATING CIRCUITRY

FIELD OF THE INVENTION

[0001] The present invention relates to ECG monitoring and gating systems, and specifically to improved systems and methods for measuring the impedance at the electrode-body interface.

BACKGROUND OF THE INVENTION

[0002] Everyday, in hospitals around the world, the electrical activity of humans and animals is measured by countless doctors and veterinarians through the use of electrodes. In some instances, an ECG of the heart is taken to monitor or measure heart abnormalities. Other patients have brainwaves monitored or measured through an EEG. Still other patients require stress tests. Additionally, defibrillators apply electricity to patients through electrodes to stimulate the patient's heart. Through all these procedures and tests, the interface between the patient and the electrode, the electrode-body interface, controls the quality of the signal transferred through the interface. High impedance, i.e., high resistance to the flow of electricity at the electrode-body interface, may result in poor signal transmission.

[0003] The quality of the electrical signal transferred through the electrode-body interface affects each one of the above mentioned procedures. For an ECG measurement, whether the measurement is simply to monitor the patient's heart cycle or to trigger or gate a device, such as a gamma camera, to record an image of the heart, noise in the signal can negatively affect the results. Noise in the signal can cause improper triggering of the gamma camera and require multiple tests. Additionally, poor electrical signal transfer through the electrode-body interface can cause burning of the skin during defibrillation.

[0004] Currently, medical staff attempt to reduce the impedance at the electrode-body interface by eliminating all interfering substances from the skin surface. Medical staff, including nurses and technicians, scrub and cleanse the skin's surface to remove excess debris, oil, hair and any other particles that could raise the impedance at the electrode-body interface. However, without measuring the impedance at the electrode-body interface, the medical staff have no concrete indicator of the impedance of the interface.

[0005] Most medical staff use hand-held impedance measurement devices that can measure the impedance at the electrode-body interface. However, these devices are clumsy and time consuming. Each electrode has to be measured individually and each medical staff member has to carry an electrode impedance measuring device.

[0006] An early warning system is needed to alert medical technicians that the patient preparation is not finished, and that preparation needs to be continued until an acceptable electrode-body impedance is reached. Therefore, a need exists to automate and facilitate the process of measuring the impedance at the electrode-body interface and provide an early warning system of improper electrical impedance.

SUMMARY OF THE INVENTION

[0007] In satisfaction of these needs and others, the present invention relates to automating the measurement of impedance at the electrode-body interface.

[0008] In one aspect, the present invention relates to a system for measuring the impedance at the electrode-body interface. The system includes a processor, an alternating current generator in communication with the processor, and a plurality of electrodes in communication with the processor and the alternating current generator. The processor calculates the impedance at the electrode-body interface using the output impedance and output voltage of the alternating current generator and the voltage between one or more of the electrodes.

[0009] In some embodiments, the alternating current generator provides a constant current output. In these embodiments, the impedance at the electrode-body interface is linearly related to the voltage between one or more of the electrodes.

[0010] In some embodiments, the system further includes a plurality of switches, each of which is associated with a respective electrode. In some of these embodiments, the switches are field effect transistors.

[0011] In some embodiments, the system further includes a synchronous rectifier in electrical communication between the processor and the electrodes. In some of these embodiments, the synchronous rectifier is also in communication with the alternating current generator. The synchronous rectifier samples the peak amplitude of a waveform generated by the alternating current generator.

[0012] In some embodiments, the plurality of electrodes includes three electrodes. The voltage between the electrodes is then calculated by paralleling two of the electrodes while measuring the voltage between the parallel electrode and the third electrode.

[0013] In some embodiments, the alternating current generator operates at 10 hertz and generates a triangular voltage waveform. The alternating current generator in some embodiments generates currents of less than 10 microamps.

[0014] In some embodiments, the system further includes an analog to digital converter in electrical communication between the processor and the synchronous rectifier.

[0015] Another aspect of the present invention relates to incorporating the system for measuring the ECG impedance at the electrode-body interface into other systems or clinical devices such as a gamma camera system, a stress testing system, a defibrillator system, an EEG system, a transcutaneous nerve stimulator, a depth of anesthesia monitoring system, an EMG monitor, a CT scanner, a MRI, an ultrasound, a lithotripter, and any other device for which skin electrodes are required for measurement or current delivery. The user of each of the enumerated systems is automatically notified of the electrode-body impedance.

[0016] Yet another aspect of the present invention relates to a method for measuring the impedance at the body-electrode interface in a system that includes an alternating current generator and a plurality of electrodes. The method includes measuring an output impedance and an output voltage of the alternating current generator, measuring a voltage between two or more of a plurality of electrodes in communication with the alternating current generator and calculating the impedance at the electrode-body interface using the output impedance and output voltage of the alternating current generator and the voltage between two or more electrodes.

[0017] In some embodiments, the alternating current generator provides a constant current output. In these embodiments, the impedance at the electrode-body interface is linearly related to the voltage between one or more of the electrodes.

[0018] In some embodiments, the plurality of electrodes comprises three electrodes. The voltage between two or more electrodes is then calculated by paralleling two of the electrodes while measuring the voltage between the parallel electrode and the third electrode.

[0019] In some embodiments, the alternating current generator operates at 10 hertz and generates a triangular voltage waveform. The alternating current generator in one embodiment generates currents of less than 10 microamps.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] These embodiments and other aspects of this invention will be readily apparent from the description below and the appended drawings, which are meant to illustrate and not to limit the invention, and in which:

[0021] Fig. 1 is a schematic diagram illustrating an automated electrode-body interface impedance measurement circuit according to an embodiment of the present invention;

[0022] Fig. 2 is a schematic diagram illustrating an automated electrode-body interface impedance measurement circuit according to an embodiment of the present invention; and

[0023] Fig. 3 is a high-level flow chart illustrating exemplary steps involved in calculating electrode-body interface impedance according to an embodiment of the present invention.

DESCRIPTION

[0024] The present invention will be more completely understood through the following description, which should be read in conjunction with the attached drawings. In this description, like numbers refer to similar elements within various embodiments of the present invention. Within this description, the claimed invention will be explained with respect to embodiments. However, the skilled artisan will readily appreciate that the methods and systems described herein are merely exemplary and that variations can be made without departing from the spirit and scope of the invention.

[0025] In general, the present invention relates to a system and method for determining the impedance of an electrode, for example a skin electrode, at the electrode-body interface. The electrode may be used in ECG and EEG gating and monitoring, defibrillators, stress testing, transcutaneous nerve stimulators, depth of anesthesia monitoring systems, EMG monitors, CT scanners, MRIs, ultrasounds, lithotripters, and any other device for which skin electrodes are required for measurement or current delivery. The electrode-body impedance of one of the electrodes may be calculated using the voltage difference between that electrode and a plurality of other electrodes, and the voltage and impedance of an alternating current generator in communication with the electrodes.

[0026] Fig. 1 is a highly schematic diagram illustrating an automated electrode-body interface impedance measurement system, according to an embodiment of the present invention. In one embodiment, the impedance measurement system 8 includes a processor 10, an alternating current generator 12, a switch 22, and a plurality of electrodes. In one embodiment, there is a first electrode 16, a second electrode 18, and a third electrode 20.

[0027] In one embodiment, a plurality of electrodes, for example three electrodes 16-20, are connected to the switch 22. The switch 22 is in electrical communication with both the alternating current generator 12 and the processor 10 and permits the user to select the appropriate electrodes 16-20 for the selected impedance measurement, for example, the first electrode 16. The processor 10 controls both the alternating current generator 12 and the switch 22. The processor 10 turns on the alternating current generator 12, to enable the impedance measurement, and turns off the alternating current generator 12 after the calculation has been completed. The alternating current generator 12 applies a voltage through the switch 22, which causes a current to flow to the first electrode 16, through the patient, to the second electrode 18 and the third electrode 20, which may be paralleled. The processor 10 measures the resultant voltage and uses that voltage along with the impedance of and voltage of the alternating current generator 12 to calculate the impedance of the electrodes 16-20. The measurement and calculation is then repeated for each of the two remaining electrodes 18 and 20.

[0028] With continued reference to Fig. 1, the electrodes may be any electrode used by one of skill in the art to measure electrical activity in a patient. Depending on what electrical activity is being measured, there can be three, four, five, six, or more electrodes. For ECG monitoring and gating, three or more electrodes may be used. For EEG monitoring and gating as few as two and as many as 64 electrodes may be used. For a stress test, up to twelve electrodes may be used. For a defibrillator, two or more electrodes may be used. In the illustrated embodiment, three electrodes are shown to measure the ECG of a patient. Although other types of measurements are possible and more electrodes may be used, in discussing the aspects of the present invention, an exemplary three electrodes will be used in connection with an ECG monitor.

[0029] With continued reference to Fig. 1, the alternating current generator 12 may be a 10 hertz generator that produces an alternating current which is applied to the electrodes 16-20. The alternating current generator 12 may produce a current in the range or 10-15 microamps RMS. The alternating current generator 12 may produce a variety of waveforms, including triangular or square voltage waveforms. The alternating current generator 12 has an output voltage associated with it, in the range of 0.5 volts RMS to 5.0 volts RMS and an output impedance in the range 350 kohms to 450 kohms.

[0030] The voltage between the electrodes 16-20 is one parameter that is used to determine a selected electrode's impedance. Since it is difficult to have a zero ohm reference point on a patient's body, the measurement of the impedance of one electrode, for example, the first electrode 16, in one embodiment is made by paralleling, i.e. electrically shorting together, the other two electrodes, i.e. the second electrode 18 and the third electrode 20. Then, the voltage difference between the first electrode 16 and the parallel combination of the second electrode 18 and the third electrode 20 is used for the calculation of the impedance at the electrode-body interface of the first electrode 16.

[0031] In one embodiment, the current generator 12 produces a constant current output. With a constant current output, the impedance of an electrode is linearly related to the voltage between the electrodes, i.e. the impedance of the first electrode 16 is linearly related to the voltage difference between the first electrode 16 and the voltage of the parallel combination of the second electrode 18 and the third electrode 20, as governed by the following equation:

[0032] $Z_2 = kE_2$ Eqn. 1

[0033] where Z_2 is the unknown impedance, k is an empirical constant of proportionality and E_2 is the voltage difference between the first electrode 16 and the parallel combination of the second electrode 18 and the third electrode 20.

[0034] However, it may be difficult and expensive to use a constant current source. Therefore, in another embodiment, the alternating current generator 12 produces a variable current. When the alternating current generator 12 produces a variable current, the relationship between the voltage difference between the first electrode 16 and the voltage of the parallel combination of the second electrode 18 and the third electrode 20, and the impedance of the first electrode 16 is no longer linear. Rather it is governed by the following equation:

[0035] $$Z_2 = \frac{Z_1}{\frac{E_1}{E_2} - 1}$$ Eqn. 2

[0036] where Z_2 is the unknown impedance of the first electrode 16, Z_1 is the impedance of the alternating current generator 12, E_1 is the output voltage of the alternating current generator 12, and E_2 is the voltage difference between the first electrode 16 and the parallel combination of the second electrode 18 and the third electrode 20. The output voltage and the impedance of the alternating current generator 12 are set values that are set by either the medical staff or set upon manufacture of the impedance measurement system 8.

[0037] With continued reference to Fig. 1, the processor 10, in various embodiments, is a microprocessor, a desktop or laptop computer, an embedded chip, or any type of processor that can be pre-programmed to perform calculations based on the measured voltages and impedance. The processor 10 controls the alternating current generator 12 and performs the impedance calculations. As discussed above, the type of calculation that the processor 10 performs is based on the whether the current output of the alternating current generator 12 is variable or constant. If the output current is constant, the processor 10 will perform the calculation in Eqn. 1 to determine the unknown impedance. If the output current is variable, the processor 10 will perform the calculation in Eqn. 2 to determine the unknown impedance.

[0038] In some embodiments, the processor may also control a signal to trigger or gate another device, such as an ECG monitor or a gamma camera.

[0039] Fig. 2 is a more detailed schematic diagram of the system of Fig. 1, illustrating an automated electrode-body interface impedance measurement system according to an embodiment of the present invention. In this embodiment, the impedance measurement system 8 includes a processor 10; an alternating current generator 12; a plurality of electrodes (a first electrode 16, a second electrode 18, and a third electrode 20); two sets of switches (a first switch set 22 and a second switch set 24); a switch logic device 26; a synchronous rectifier 28; a plurality of isolators (a first isolator 30 and a second isolator 32); an analog to digital converter 34; a display 36; and optionally a clinical device 38.

[0040] In one embodiment, a plurality of electrodes, preferably three, are connected to a first switch set 22 and a second switch set 24. Each switch set 22 and 24 contain one or more internal switches. An exemplary switch set 22, 24 contains three internal switches, one for each electrode: a first internal switch 22A, a second internal switch 22B, a third internal switch 22C, a fourth internal switch 24A, a fifth internal switch 24B, and a sixth internal switch 24C. Each of the switch sets 22 and 24 are connected to the alternating current generator 12. The alternating current generator 12 applies a voltage and a current flow to the three electrodes 16-20. In this embodiment, the switch sets 22 and 24 and the alternating current generator 12 are controlled by the switch logic device 26, which is in turn controlled by the processor 10. The processor 10 turns on the switch logic device 26, the synchronous rectifier 28, the analog to digital converter 34, and the alternating current generator 12 (to apply a voltage to the electrodes 16-20), and sets the switch sets 22 and 24 and the internal switches 22A-C and 24A-C.

[0041] Once the impedance measurement system 8 is turned on, the impedance of each of the electrodes is measured. For example, a signal, corresponding to the voltage difference between the first electrode 16 and the paralleled second electrode 18 and third electrode 20, is rectified by the synchronous rectifier 28 and converted to a digital signal by the analog to digital converter 34, after passing through the isolator 30. The voltage difference is then read by the processor 10. The processor 10, using the above equations, will use this voltage value alone where the generator 12 is a constant current generator or in combination with the voltage and impedance of the alternating current generator 12, if the generator 12 is variable, to calculate the impedance of the first electrode 16. Once the processor 10 has performed the calculation, the display 36 will register a value for the electrode-body impedance of the first electrode 16. The process is then repeated first for the second electrode 18 and then for the third electrode 20. The process of calculating all three electrode-body impedance values may take approximately 0.4 to 1.0 seconds, but preferably 0.6 seconds. Additionally, a clinical device 36 may also be controlled by the processor 10 and connected to the impedance measurement system 8. Once the calculation of the electrode-body impedance of all three electrodes is completed, the processor shuts off the synchronous rectifier 26, the alternating current generator 12, and the analog to digital to converter 34.

[0042] With continued reference to Figure 2, the plurality of switches are not limited to two switch sets 22, 24, but can include any number of switch sets 22, 24 necessary for the number of electrodes being used. The switch sets 22, 24 may be used to isolate the appropriate electrode. For example, if the impedance of the first electrode 16 is to be measured, the switch sets 22, 24 will be set to create a circuit between the first electrode 16 and the paralleled second electrode 18 and the third electrode 20. More specifically, the first internal switch 24A (corresponding to the first electrode 16) will be closed and the second and third internal switches 22B and 22C (corresponding to the second electrode 18 and the third electrode 20, respectively) will remain open in the first switch set 22. In the second switch set, the fifth and sixth internal switches 24B and 24C (corresponding to the second electrode 18 and the third electrode 20) will be closed, while the fourth internal switch 24A (corresponding to the first electrode 16) will remain open. In one embodiment, the first switch set 22 and the second switch set 24 comprise field effect transistor ("FET") switches.

[0043] The switch logic device 26 controls the switches 22 and 24, through the processor 10. In one embodiment, the processor 10 produces a digital output to the switch logic device 26. For example, upon receipt of the first digital output from the processor 10, the switch logic device 26 turns on the alternating current generator 12. The switch logic device 26 then directs the first switch set 22 to close the first internal switch 22A and open the second and third internal switches 22B, 22C. A third digital output causes the second switch 24 to open fourth internal switch 24A and close the fifth and sixth internal switches 24B, 24C. Upon receipt of the fourth pulse, the switch logic device 26 turns off the alternating current generator 12. The sequence may be repeated to determine the impedance of the second electrode 18 and the third electrode 20. The alternating current generator 12 is shut off as the alternating current generator 12 may cause interference with the ECG signal when the impedance measurement system 8 is used with, for example, an ECG monitoring or gating device.

[0044] The synchronous rectifier 28 rectifies the signal from the alternating current generator 12. A full wave rectifier may be used, but the use of a synchronous rectifier expedites the sampling of the peak amplitude of the waveform generated by the alternating current generator 12.

[0045] The plurality of isolators (the first isolator 30 and the second isolator 32) are used to isolate the patient or body 10 from the high voltage electronics. The first isolator 30 and the second isolator 32 may be optical isolators, transformers, or analog isolators.

[0046] The analog to digital converter 34 converts the analog signal from the synchronous rectifier 28 into a digital signal to be read by the processor 10. As illustrated, the analog to digital converter 34 is on the non-isolated side of the impedance measurement system 8. However, in other embodiments, the analog to digital converter may be located on the isolated side of the impedance measurement system 8.

[0047] The display 36 may be any device known to one of skill in the art to display the output of a processor, such as a computer monitor or a LCD screen. The display 36 may show the electrode-body impedance for all of the electrodes used in the monitoring or triggering process to be performed. Three electrodes are illustrated in Figure 2, thus, the display 36 will show the impedance of the first electrode 16, the second electrode 18, and the third electrode 18.

[0048] Other embodiments of the display 36 may include a series of blinking lights to indicate the impedance level at the electrode-body interface. For example a pair of red and green lights may be used: red signaling that the impedance is too high, green signaling an acceptable impedance. Additionally, three lights, red, green and yellow may be used, where yellow serves as a warning that the impedance may not be at an optimal level. A user, such as the medical staff, or the service provider for the system, may pre-configure the impedance levels for each of the blinking lights. Alternatively, an alarm may sound when the impedance level of the electrode-body interface for an electrode is too high. The alarm signals to the medical staff to continue to prepare the patient.

[0049] Another aspect of the invention relates to implementing the impedance measurement system 8 within the clinical device 38. The clinical device 38 may be, but is not limited to, the following: a gamma camera, a stress test ECG, an EEG machine, an EEG monitor, a transcutaneous nerve stimulator, a depth of anesthesia monitoring system, an EMG monitor, a CT scanner, a MRI, an ultrasound, a lithotripter, a defibrillator, or any other device for which skin electrodes are required for measurement or current delivery. The impedance measurement system 8 functions as described above. Once the impedance is measured, the medical staff may proceed to implement the clinical device 38. In one embodiment, the impedance measurement system 8 simply alerts the user of the other device of the impedance level at the electrode-body interface. Once the medical staff is alerted, the medical staff may proceed with the operation of the clinical device 38 or the medical staff may continue the preparation of the patient. In one embodiment, the impedance measurement system 8 will shut off the clinical device, such that the clinical device 38 will not operate until the impedance at the electrode-body interface has reached a pre-set level.

[0050] Fig. 3 is a high-level flow chart illustrating exemplary steps involved in calculating electrode-body interface impedance according to an embodiment of the present invention. The steps include (1) measuring an output impedance of the alternating current generator (Step 100); (2) measuring an output voltage of the alternating current generator (Step 102); (3) measuring a voltage between two or more electrodes (Step 104); and (4) calculating an impedance at the electrode-body interface (Step 106). The calculation of the impedance at the electrode-body interface is performed using either Eqn. 1 or Eqn. 2 above, depending of whether the alternating current produces a constant current or a variable current, respectively.

[0051] Variations, modification, and other implementations of what is described herein will occur to those of ordinary skill in the art without departing from the spirit and scope of the invention as claimed. Accordingly, the invention is to be defined not by the preceding illustrative description but instead by the spirit and scope of the following claims.

[0052] What is claimed is:

CLAIMS

1. A system for measuring the impedance at the electrode-body interface comprising:

a processor;

an alternating current generator in communication with the processor, the alternating current generator having an output voltage and an output impedance; and

a plurality of electrodes in communication with the processor and the alternating current generator, each electrode having an electrode-body impedance,

wherein the processor calculates the impedance at the electrode-body interface in response to the output impedance of the alternating current generator, the output voltage of the alternating current generator and the voltage between two or more of the electrodes.

2. The system of claim 1 wherein the alternating current generator provides a constant current output.

3. The system of claim 2 wherein the impedance at the electrode-body interface is linearly related to the voltage between two or more of the electrodes.

4. The system of claim 1 further comprising a plurality of switches, each switch associated with a respective electrode.

5. The system of claim 4 wherein the switches are field effect transistors.

6. The system of claim 1 further comprising a synchronous rectifier in electrical communication between the processor and the electrodes.

7. The system of claim 6 wherein the synchronous rectifier is further in communication with the alternating current generator and samples the peak amplitude of a waveform generated by the alternating current generator.

8. The system of claim 1 wherein the plurality of electrodes comprise three electrodes.

9. The system of claim 8 wherein the voltage between two or more of the electrodes is measured by paralleling two of the electrodes while measuring the voltage of the third electrode.

10. The system of claim 1 wherein the alternating current generator operates at a frequency of 10 Hz.

11. The system of claim 1 wherein the alternating current generator generates a current of less than 50 microamps RMS.

12. The system of claim 1 wherein the alternating current generator generates a current of 10 microamps RMS.

13. The system of claim 1 wherein the alternating current generator generates a triangular voltage waveform.

14. The system of claim 1 further comprising an analog to digital converter in electrical communication between the processor and the synchronous rectifier.

15. The system of claim 1 further comprising an analog to digital converter in electrical communication between the processor and the electrodes.

16. A gamma camera system comprising:

a gamma camera; and

an impedance measuring device in electrical communication with the gamma camera comprising:

a processor;

an alternating current generator in communication with the processor, the alternating current generator having an output voltage and an output impedance; and

a plurality of electrodes in communication with the processor and the alternating current generator, each electrode having an electrode-body impedance,

wherein the processor calculates the impedance at the electrode-body interface in response to the output impedance of the alternating current generator, the output voltage of the alternating current generator and the voltage between two or more of the electrodes,

wherein the user of the gamma camera is notified of the electrode-body impedance of the plurality of electrodes.

17. A stress testing system comprising:

an ECG device for stress testing; and

an impedance measuring device in electrical communication with the ECG stress testing system comprising:

a processor;

an alternating current generator in communication with the processor, the alternating current generator having an output voltage and an output impedance; and

a plurality of electrodes in communication with the processor and the alternating current generator, each electrode having an electrode-body impedance,

wherein the processor calculates the impedance at the electrode-body interface in response to the output impedance of the alternating current generator, the output voltage of the alternating current generator and the voltage between two or more of the electrodes,

wherein the user of the ECG stress testing system is notified of the electrode-body impedance of the plurality of electrodes.

18. A defibrillator system comprising:

a defibrillator; and

an impedance measuring device in electrical communication with the defibrillator comprising:

a processor;

an alternating current generator in communication with the processor, the alternating current generator having an output voltage and an output impedance; and

a plurality of electrodes in communication with the processor and the alternating current generator, each electrode having an electrode-body impedance,

wherein the processor calculates the impedance at the electrode-body interface in response to the output impedance of the alternating current generator, the output voltage of the alternating current generator and the voltage between two or more of the electrodes,

wherein the user of the defibrillator is notified of the electrode-body impedance of the plurality of electrodes.

19. A EEG system comprising:

an EEG device; and

an impedance measuring device in electrical communication with the EEG device comprising:

a processor;

an alternating current generator in communication with the processor, the alternating current generator having an output voltage and an output impedance; and

a plurality of electrodes in communication with the processor and the alternating current generator, each electrode having an electrode-body impedance,

wherein the processor calculates the impedance at the electrode-body interface in response to the output impedance of the alternating current generator, the output voltage of the alternating current generator and the voltage between two or more of the electrodes,

wherein the user of the EEG device is notified of the electrode-body impedance of the plurality of electrodes.

20. A clinical system comprising:

a plurality of electrodes for attachment to a body of a patient and each of said electrodes having electrode-body impedance;

a clinical device in communication with the electrodes; and

an impedance measuring device in electrical communication with the clinical device, the impedance measuring device comprising:

a processor in communication with the electrodes; and

an alternating current generator in communication with the processor and the plurality of electrodes, the alternating current generator having an output voltage and an output impedance;

wherein the processor calculates the impedance at the electrode-body interface in response to the output impedance of the alternating current generator, the output voltage of the alternating current generator and the voltage between two or more of the electrodes,

wherein the user of the clinical device is notified of the electrode-body impedance of the plurality of electrodes.

21. The system of claim 20 wherein the clinical device is a device for which skin electrodes are required for one of measurement or current delivery.

22. The system of claim 21 wherein the clinical device is selected from the group consisting of a transcutaneous nerve stimulator, a depth of anesthesia monitoring system, an EMG monitor, a CT scanner, a MRI, an ultrasound, or a lithotripter.

23. A method for measuring the impedance of the body-electrode interface in a system comprising an alternating current generator and a plurality of electrodes, the method comprising:

measuring an output impedance of the alternating current generator;

measuring an output voltage of the alternating current generator;

measuring a voltage between two or more electrodes of a plurality of electrodes in communication with the alternating current generator; and

calculating an impedance at the electrode-body interface using the output impedance of an alternating current generator, the output voltage of the alternating current generator and the voltage between two or more electrodes.

24. The method of claim 23 wherein the alternating current generator provides a constant current output.

25. The method of claim 24 wherein the impedance at the electrode-body interface is linearly related to the voltage between two or more of the electrodes.

26. The method of claim 23 wherein the plurality of electrodes comprises three electrodes.

27. The method of claim 26 wherein the voltage between two or more electrodes is measured by paralleling two of the electrodes while measuring the voltage between the paralleled electrodes and the third electrode.

28. The method of claim 23 wherein the alternating current generator operates at a frequency of 10 Hz.

29. The method of claim 23 wherein the alternating current generator generates a current of less than 50 microamps RMS.

30. The method of claim 23 wherein the alternating current generator generates a current of 10 microamps RMS.

31. The method of claim 23 wherein the alternating current generator generates a triangular voltage waveform.

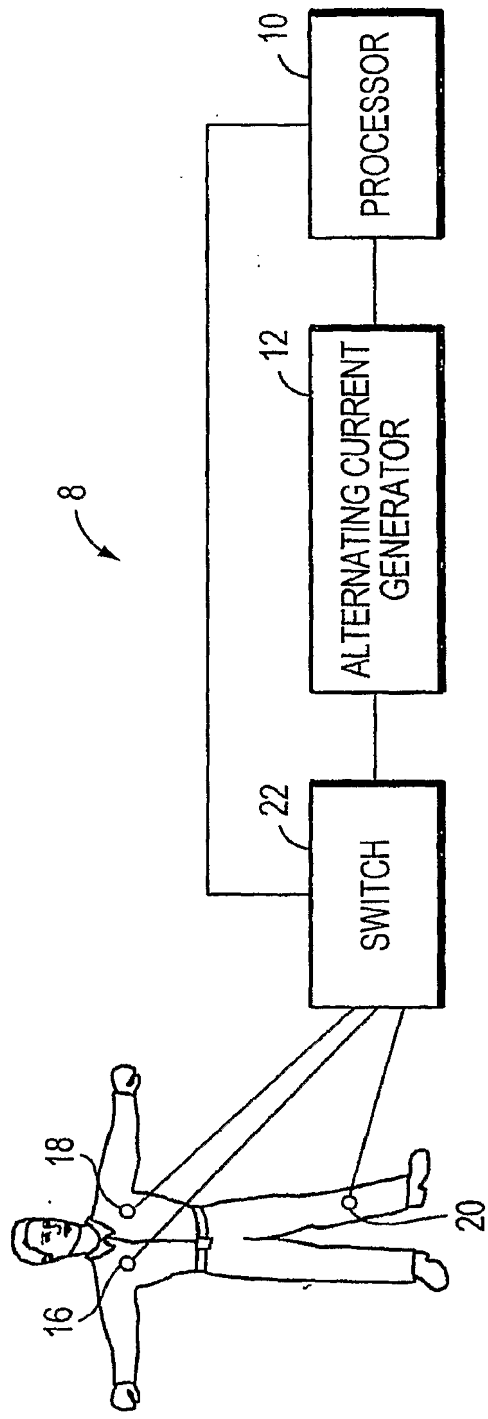
PROCESSOR
10
ALTERNATING CURRENT GENERATOR
12
SWITCH
22
8
16
18
20

FIG. 1

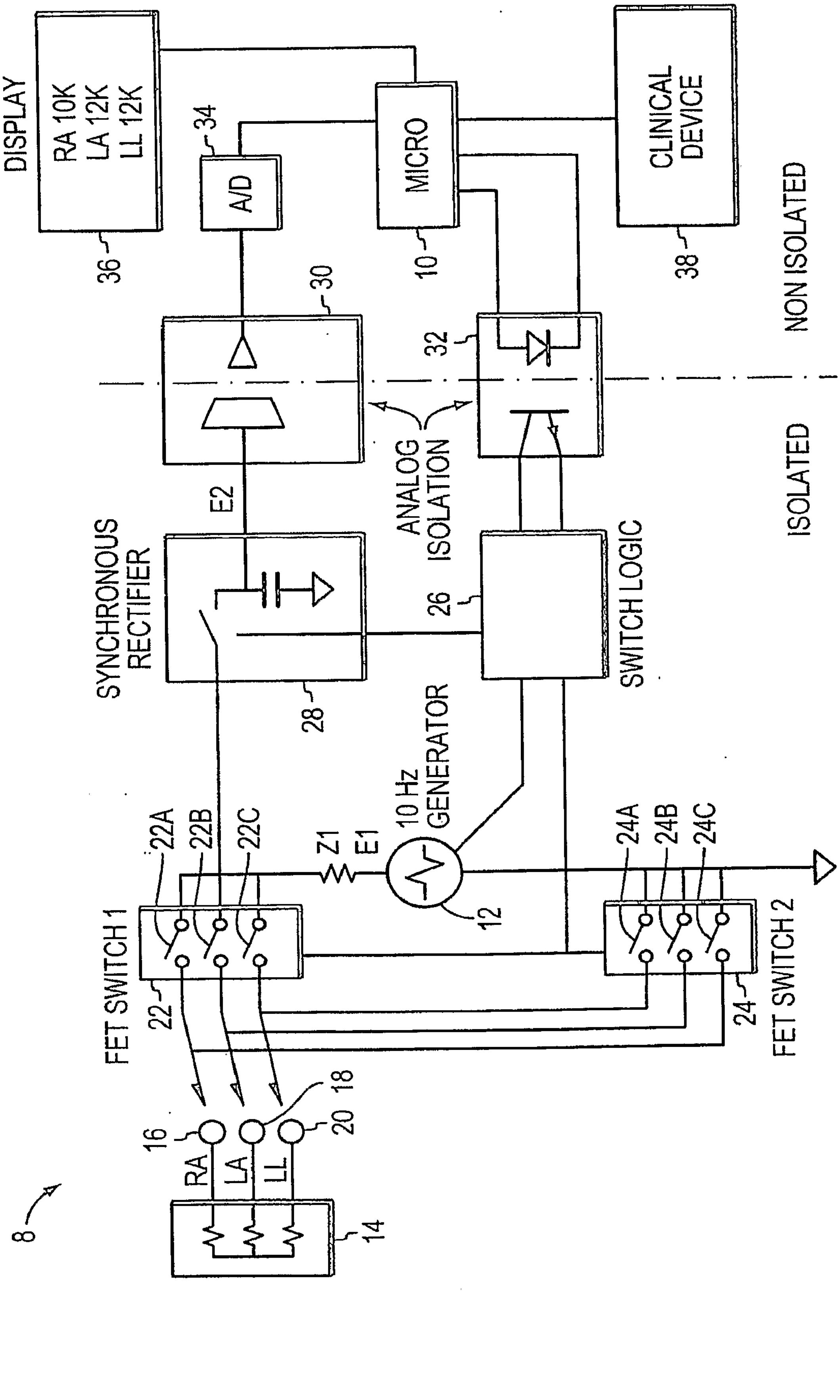
DISPLAY
RA 10K
LA 12K
LL 12K
36
A/D
34
MICRO
10
CLINICAL DEVICE
38
30
32
NON ISOLATED
ISOLATED
ANALOG ISOLATION
SYNCHRONOUS RECTIFIER
28
E2
SWITCH LOGIC
26
10 Hz GENERATOR
12
Z1
E1
22A
22B
22C
FET SWITCH 1
22
24A
24B
24C
FET SWITCH 2
24
16
18
20
RA
LA
LL
14
8

FIG. 2

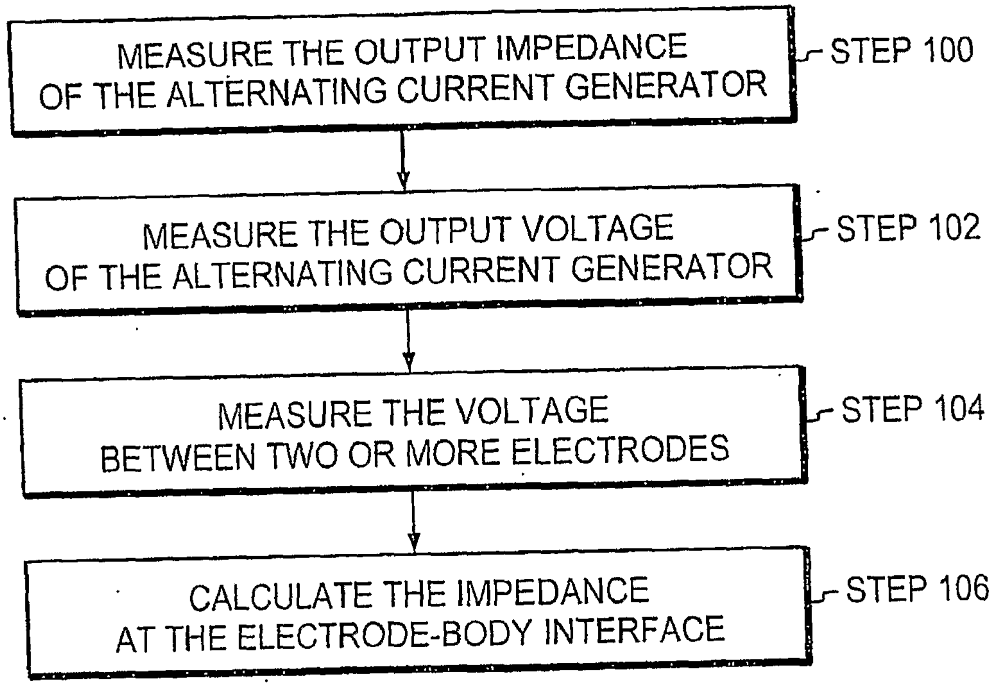
MEASURE THE OUTPUT IMPEDANCE
OF THE ALTERNATING CURRENT GENERATOR
STEP 100
MEASURE THE OUTPUT VOLTAGE
OF THE ALTERNATING CURRENT GENERATOR
STEP 102
MEASURE THE VOLTAGE
BETWEEN TWO OR MORE ELECTRODES
STEP 104
CALCULATE THE IMPEDANCE
AT THE ELECTRODE-BODY INTERFACE
STEP 106

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/018391

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B G01R G01T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 245 643 A (BENZING III GEORGE ET AL) 20 January 1981 (1981-01-20)	1-3,11, 12,20, 23-35
A	column 4, line 20 - column 5, line 65	16-19
A	EP 0 182 197 A (SPACELABS INC [US]) 28 May 1986 (1986-05-28) the whole document	1,4
A	JP 02 243988 A (TOKYO SHIBAURA ELECTRIC CO) 28 September 1990 (1990-09-28) the whole document	16
A	US 5 337 230 A (BAUMGARTNER RICHARD A [US] ET AL) 9 August 1994 (1994-08-09) abstract	18

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

☒ See patent family annex.

* Special categories of cited documents :

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

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 January 2008	21/01/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Manschot, Jan

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2007/018391

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 4245643	A	20-01-1981	BE	884781 A1	01-12-1980
			DE	3029786 A1	11-06-1981
			FR	2462898 A1	20-02-1981
			GB	2058368 A	08-04-1981
			JP	56060548 A	25-05-1981
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			CN	85108601 A	10-09-1986
JP 2243988	A	28-09-1990	NONE		
US 5337230	A	09-08-1994	EP	0570101 A2	18-11-1993
			JP	3504685 B2	08-03-2004
			JP	6217944 A	09-08-1994

patsnap

专利名称(译)	自动ECG导联阻抗测量集成到ECG门控电路中		
公开(公告)号	EP2077749A1	公开(公告)日	2009-07-15
申请号	EP2007837071	申请日	2007-08-20
[标]申请(专利权)人(译)	IVY生物医学SYST		
申请(专利权)人(译)	IVY生物医学系统，INC.		
当前申请(专利权)人(译)	IVY生物医学系统，INC.		
[标]发明人	MENTELOS RICHARD ALAN		
发明人	MENTELOS, RICHARD, ALAN		
IPC分类号	A61B5/00 A61B5/0424 A61B5/053 G01R31/02 G01T1/164		
CPC分类号	A61B5/0424 A61B5/053 A61B5/6843 A61B5/7285 A61B6/541 A61B8/543 A61N1/3603 A61N1/3925		
优先权	11/509928 2006-08-25 US		
其他公开文献	EP2077749B1		
外部链接	Espacenet		

摘要(译)

本发明涉及一种用于确定电极 - 主体界面处的电极的阻抗的系统和方法。可以使用该电极和多个其他电极之间的电压差以及与电极连通的交流发电机的电压和阻抗来计算其中一个电极的电极体阻抗。