US010390756B2

(12) **United States Patent**
Youm et al.

(10) **Patent No.: US 10,390,756 B2**

(45) **Date of Patent: Aug. 27, 2019**

(54) **BIO-STIMULATING AND BIO-SIGNAL MEASURING CIRCUIT**

(71) Applicant: **Electronics and Telecommunications Research Institute**, Daejeon (KR)

(72) Inventors: **WooSub Youm**, Daejeon (KR); **Sung Q Lee**, Daejeon (KR); **Gunn Hwang**, Daejeon (KR)

(73) Assignee: **ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE**, Daejeon (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 23 days.

(21) Appl. No.: **15/424,477**

(22) Filed: **Feb. 3, 2017**

(65) **Prior Publication Data**

US 2017/0238865 A1 Aug. 24, 2017

(30) **Foreign Application Priority Data**

Feb. 22, 2016 (KR) 10-2016-0020728

(51) **Int. Cl.**

A61N 1/20	(2006.01)
A61B 5/00	(2006.01)
A61N 1/36	(2006.01)
A61B 5/0476	(2006.01)
A61B 5/0402	(2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***A61B 5/4836*** (2013.01); ***A61N 1/20*** (2013.01); ***A61N 1/36014*** (2013.01); *A61B 5/0402* (2013.01); *A61B 5/0476* (2013.01); *A61B 5/0488* (2013.01); *A61B 5/0496* (2013.01)

(58) **Field of Classification Search**

CPC A61N 1/025; A61N 1/08; A61N 1/36125; A61N 1/3704; A61N 1/3912

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,979,507 A 12/1990 Heinz et al.
5,472,454 A * 12/1995 Ozawa A61N 1/3931 607/5
5,620,474 A 4/1997 Koopman

(Continued)

FOREIGN PATENT DOCUMENTS

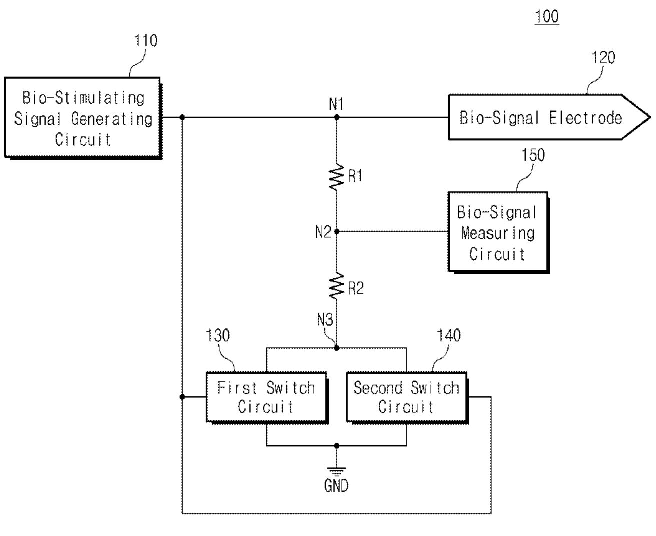
EP 0 627 241 A2 2/1989
KR 101566786 B1 11/2015

Primary Examiner — Tammie K Marlen

(57) **ABSTRACT**

The circuit may include bio-stimulating signal generating circuit which generates a bio-stimulating signal in a bio-stimulating mode, a bio-signal electrode which delivers the bio-stimulating signal generated in the bio-stimulating mode and receives a bio-signal in a bio-signal measuring mode, a switch block which is turned on when a voltage of the bio-stimulating signal is greater than a first reference voltage which is greater than a second reference voltage or lower than the second reference voltage, first and second resistors, and a bio-signal measuring circuit which measures voltage signals divided by the first and second resistors or measures a signal of the bio-signal electrode according to whether the switch block is turned on. The first and second resistors may be serially connected between the bio-signal electrode and the switch block, and divide a voltage of a signal of the bio-signal electrode when the switch block is turned on.

8 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

A61B 5/0488	(2006.01)
A61B 5/0496	(2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,649,853	B2	2/2014	Sweeney et al.		
8,892,206	B1	11/2014	Swanson		
2002/0022867	A1*	2/2002	Akiyama	A61N 1/3937	607/66
2002/0072769	A1*	6/2002	Silvian	A61N 1/08	607/2
2005/0259454	A1*	11/2005	Varrichio	A61N 1/36125	363/61
2007/0156203	A1*	7/2007	Varrichio	H02M 3/07	607/59
2010/0185076	A1	7/2010	Jeong et al.		
2010/0324619	A1*	12/2010	Wanasek	A61N 1/3625	607/10
2012/0035687	A1*	2/2012	Lu	A61N 1/36125	607/61
2013/0197338	A1	8/2013	Yu et al.		

* cited by examiner

FIG. 1

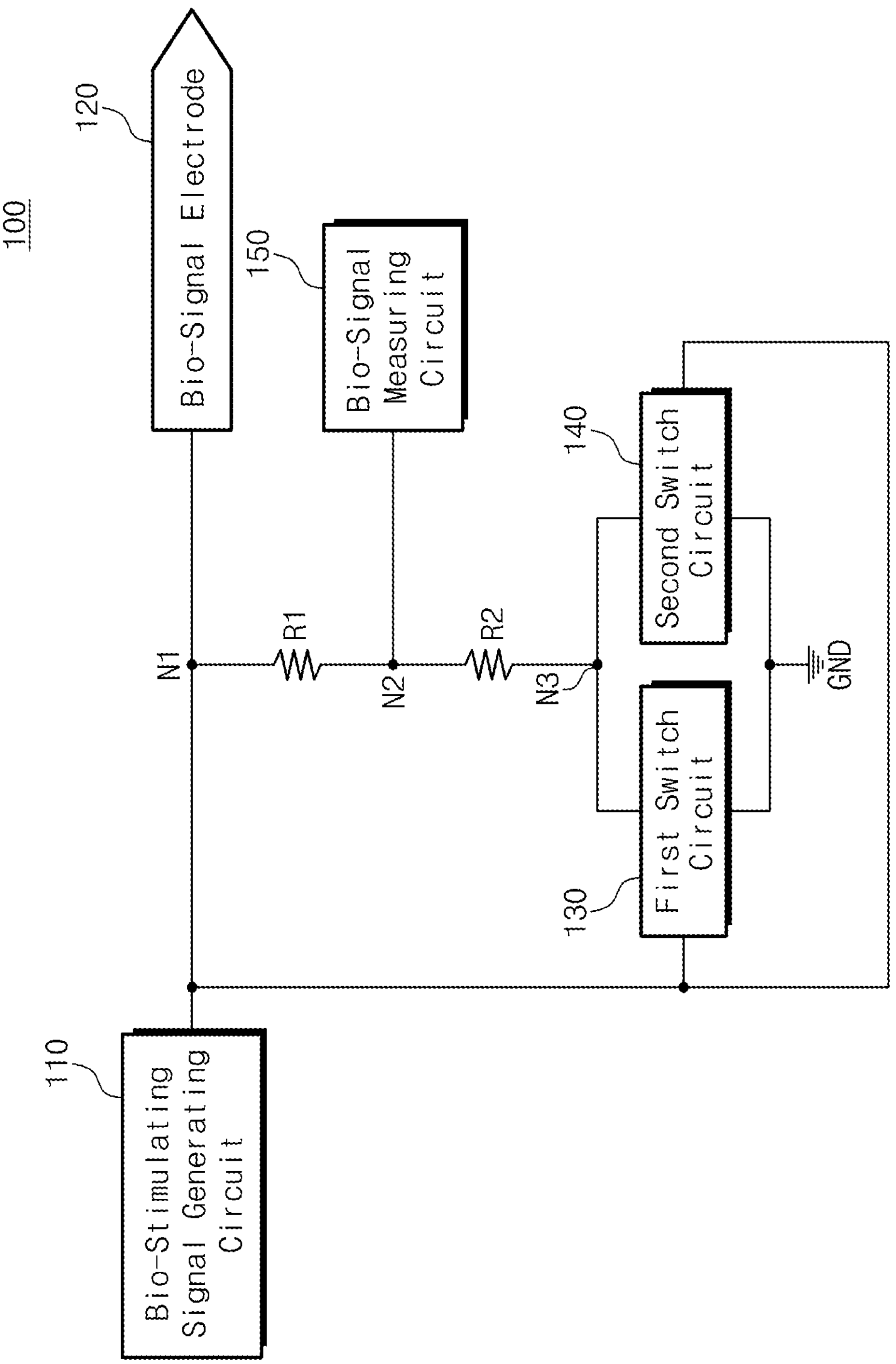

100
120
Bio-Signal Electrode
150
Bio-Signal Measuring Circuit
140
Second Switch Circuit
130
First Switch Circuit
110
Bio-Stimulating Signal Generating Circuit
N1
R1
N2
R2
N3
GND

FIG. 2

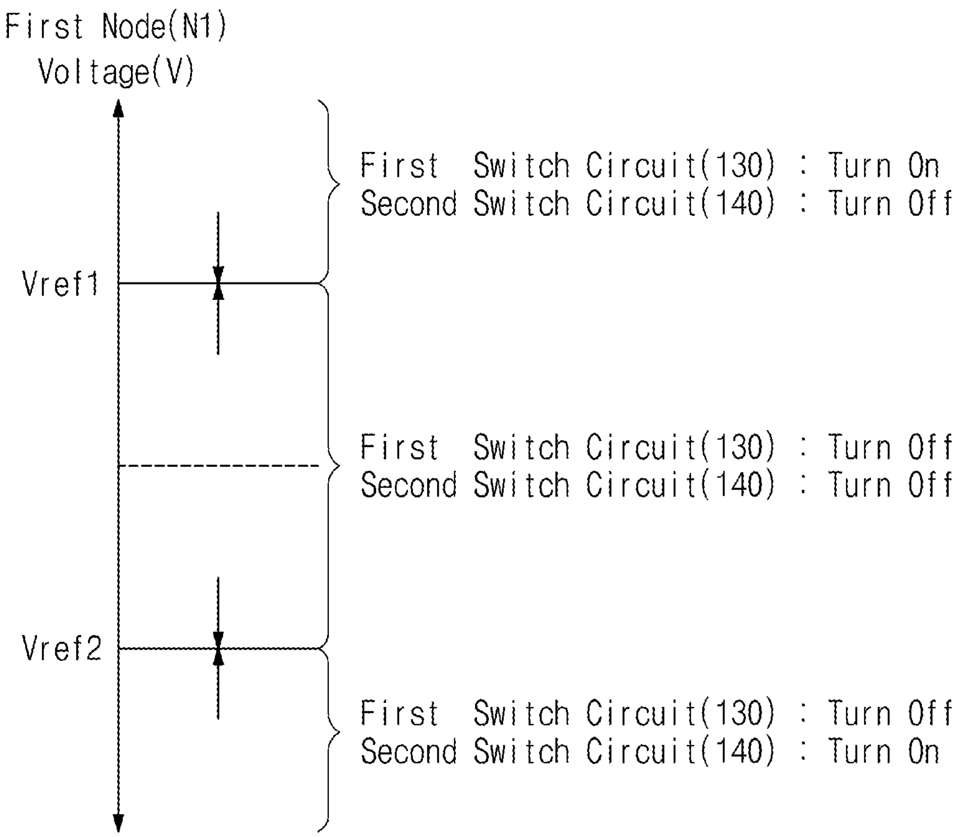
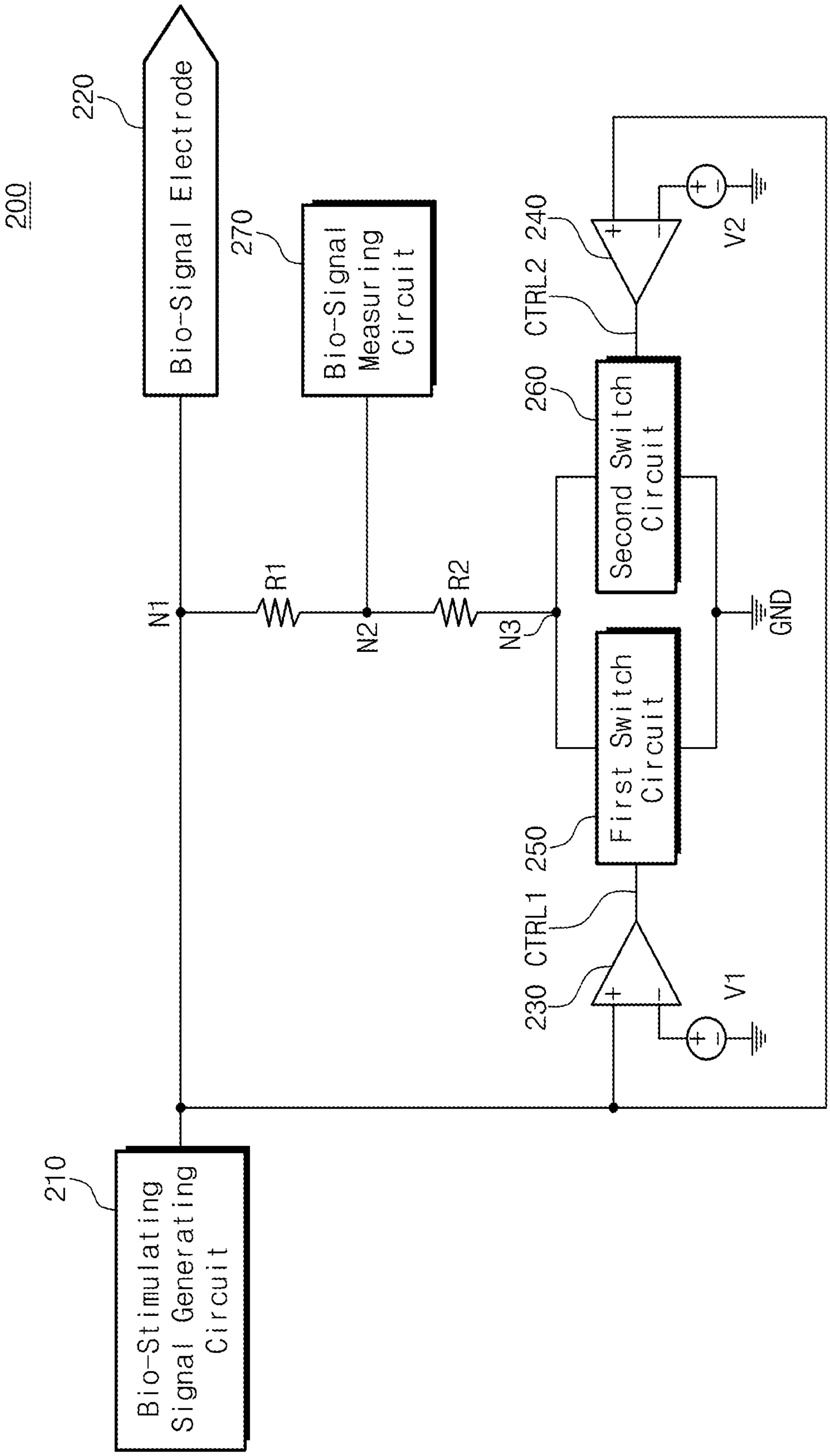

First Node(N1)
Voltage(V)
Vref1
Vref2
First Switch Circuit(130) : Turn On
Second Switch Circuit(140) : Turn Off
First Switch Circuit(130) : Turn Off
Second Switch Circuit(140) : Turn Off
First Switch Circuit(130) : Turn Off
Second Switch Circuit(140) : Turn On

FIG. 3


200
220
Bio-Signal Electrode
270
Bio-Signal Measuring Circuit
N1
R1
N2
R2
N3
260
Second Switch Circuit
250
First Switch Circuit
GND
240
CTRL2
V2
230
CTRL1
V1
210
Bio-Stimulating Signal Generating Circuit

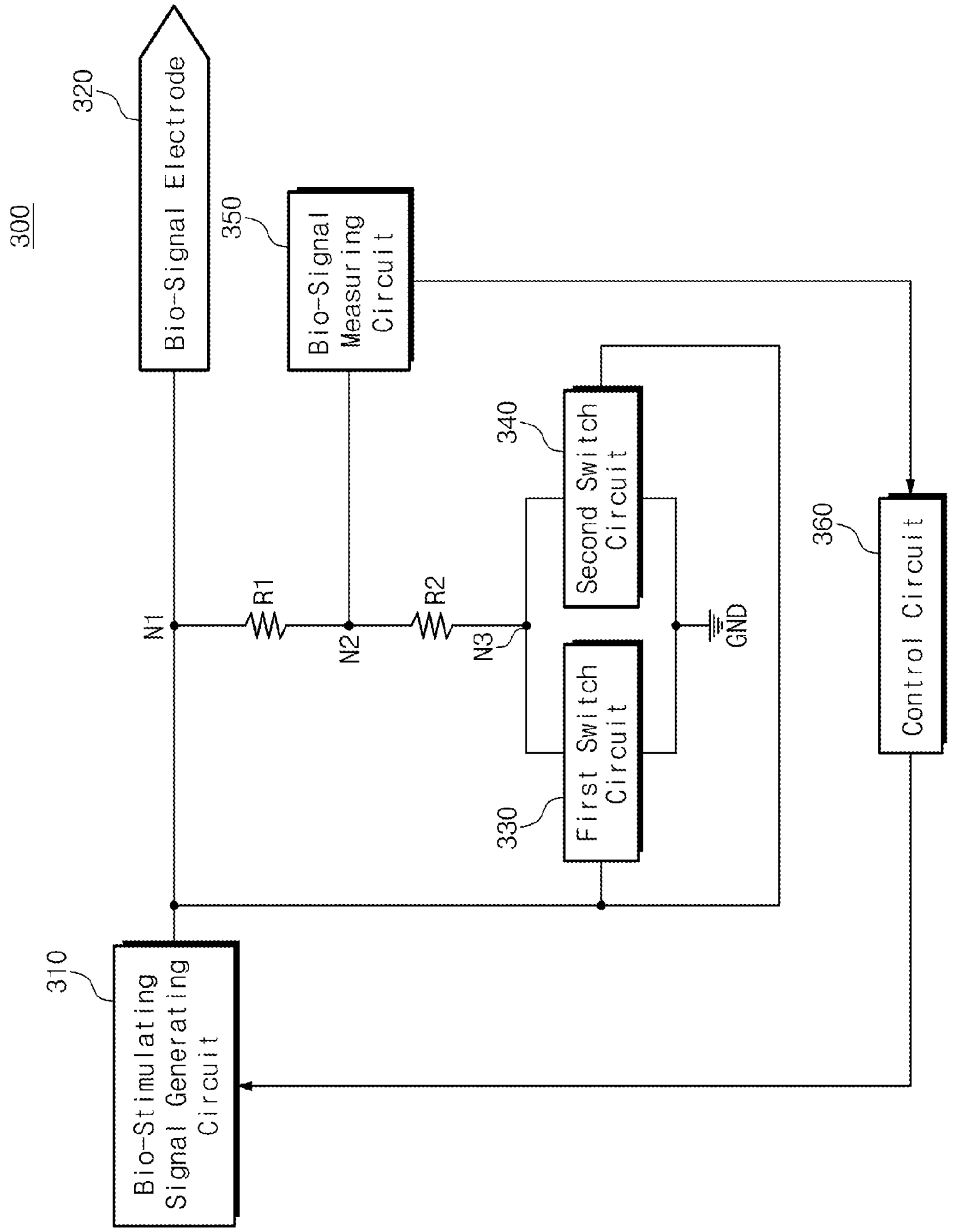
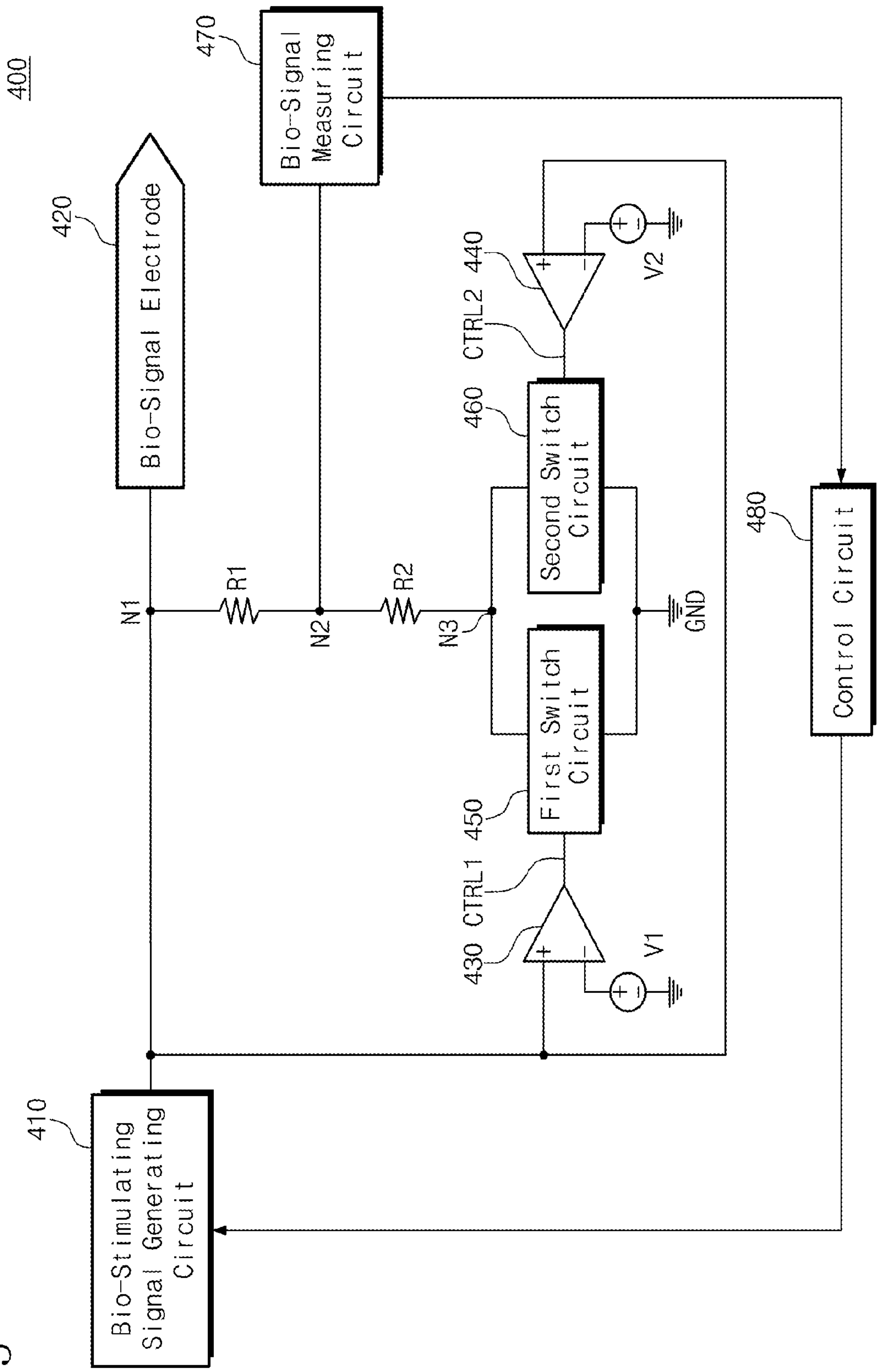

300
320
Bio-Signal Electrode
350
Bio-Signal Measuring Circuit
340
Second Switch Circuit
360
Control Circuit
N1
R1
N2
R2
N3
GND
330
First Switch Circuit
310
Bio-Stimulating Signal Generating Circuit

FIG. 4

FIG. 5



400
410
Bio-Stimulating Signal Generating Circuit
420
Bio-Signal Electrode
470
Bio-Signal Measuring Circuit
N1
R1
N2
R2
N3
GND
430
CTRL1
V1
440
CTRL2
V2
450
First Switch Circuit
460
Second Switch Circuit
480
Control Circuit

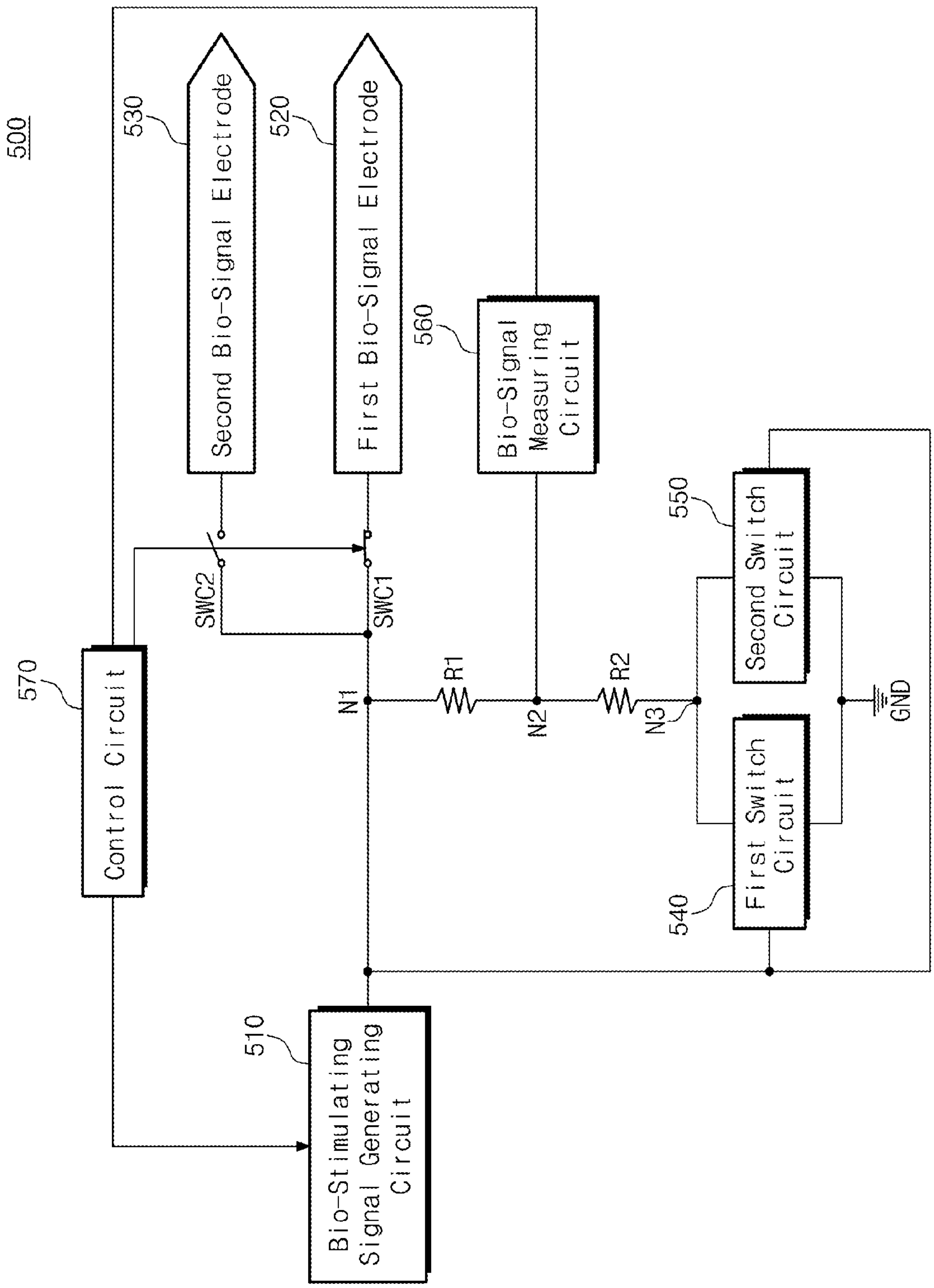

500
530
Second Bio-Signal Electrode
520
First Bio-Signal Electrode
560
Bio-Signal Measuring Circuit
550
Second Switch Circuit
540
First Switch Circuit
570
Control Circuit
510
Bio-Stimulating Signal Generating Circuit
SWC2
SWC1
N1
R1
N2
R2
N3
GND

FIG. 6

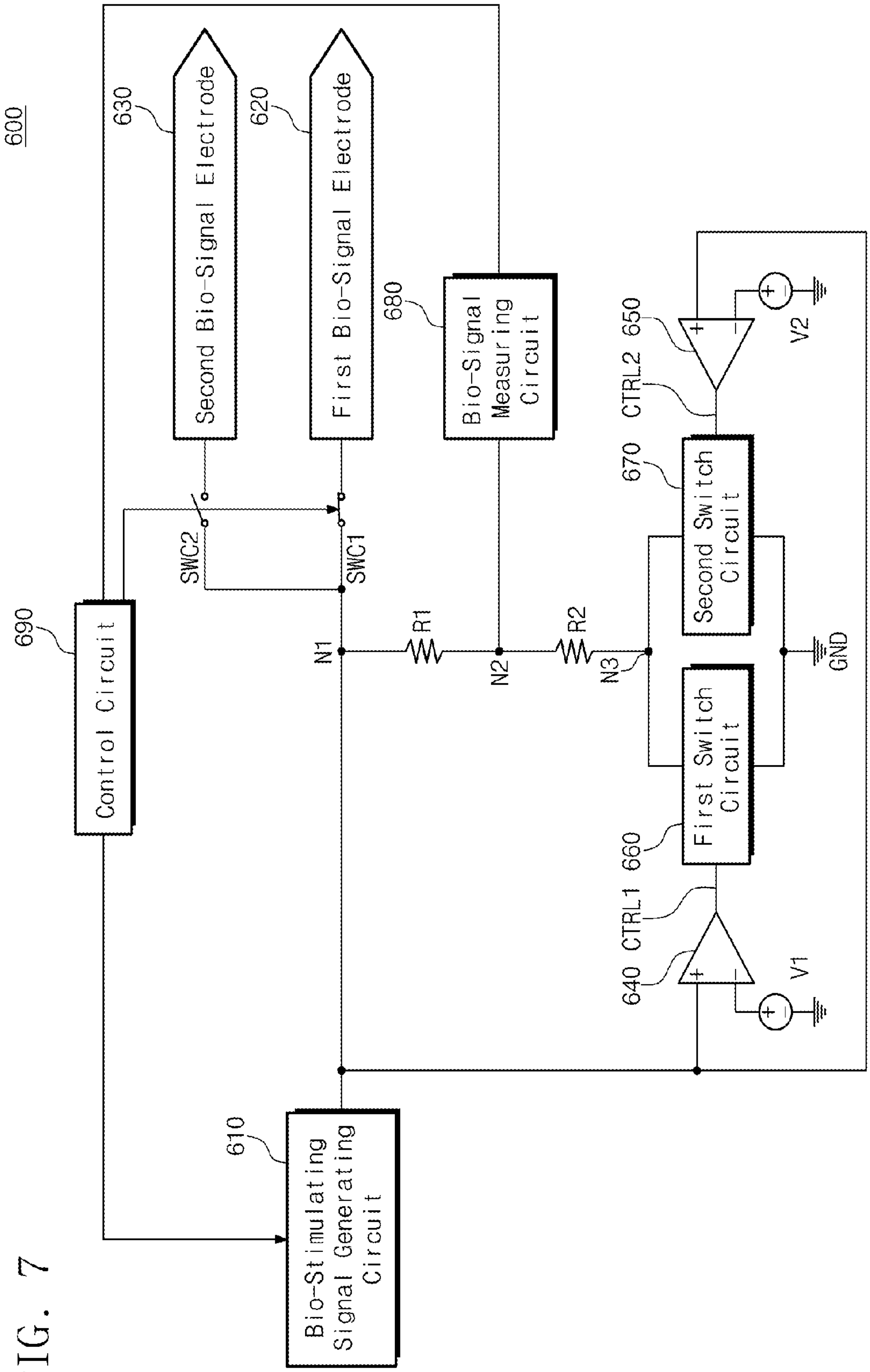

600
630
Second Bio-Signal Electrode
620
First Bio-Signal Electrode
680
Bio-Signal Measuring Circuit
690
Control Circuit
SWC2
SWC1
N1
R1
N2
R2
N3
650
CTRL2
670
Second Switch Circuit
GND
First Switch Circuit
660
CTRL1
640
V1
V2
610
Bio-Stimulating Signal Generating Circuit

FIG. 7

BIO-STIMULATING AND BIO-SIGNAL MEASURING CIRCUIT

CROSS-REFERENCE TO RELATED APPLICATIONS

This U.S. non-provisional patent application claims priority under 35 U.S.C. § 119 of Korean Patent Application No. 10-2016-0020728, filed on Feb. 22, 2016, the entire contents of which are hereby incorporated by reference.

BACKGROUND

The present disclosure herein relates to an implantable medical device, and more particularly, to a bio-stimulating and bio-signal measuring circuit.

With development in a low-power, high-density electronic circuit implementation technology and a high energy density battery technology, an implantable medical device has decreased in size, has multi-function, and has multi-channel. A deep brain stimulator or defibrillator is an example of a commercialized implantable medical device. Also, the commercialization of various implantable medical devices is in progress, such as a stomach stimulator, a foot drop treatment device, cochlear implantation, and brain computer interface (BCI) or an implantable drug pump.

The implantable medical devices are different in symptoms to be treated while most of them have the same algorithm. When an abnormal state in a corresponding bio-signal according to the symptom to be treated is detected, the implantable medical device stimulates the nerve of a specific part. The implantable medical device relieves or removes the symptom to be treated by such a stimulation signal, and allows a corresponding bio-signal to become normal.

However, in an existing implantable medical device, a bio-stimulating mode and a bio-signal measuring mode are divided. The reason is to prevent a bio-signal signal measuring circuit from becoming damaged by a bio-stimulating signal. Thus, the existing implantable medical device cannot simultaneously perform the bio-stimulating mode and the bio-signal measuring mode. Thus, the existing implantable medical device has a limitation in that it is difficult to handle an abnormal signal in real time that may be caused upon the application of the bio-stimulating signal.

SUMMARY

The present disclosure provides a bio-stimulating and bio-signal measuring circuit that automatically protects a bio-signal measuring circuit in a bio-stimulating mode and simultaneously performs bio-stimulating and bio-signal measurement with a single electrode.

An embodiment of the inventive concept provides a bio-stimulating and bio-signal measuring circuit including a bio-stimulating signal generating circuit, a bio-signal electrode, a switch block, first and second resistors, and a bio-signal measuring circuit. The bio-stimulating signal generating circuit may generate a bio-stimulating signal in a bio-stimulating mode. The bio-signal electrode may to deliver the bio-stimulating signal generated in the bio-stimulating mode and receive a bio-signal in a bio-signal measuring mode. The switch block may be turned on in a case where a voltage of the bio-stimulating signal is greater than a first reference voltage or lower than a second reference voltage. The first and second resistors may be serially connected between the bio-signal electrode and the switch block and divide a voltage of a signal of the bio-signal electrode according to whether the switch block is turned on. The bio-signal measuring circuit may measure voltage signals divided by the first and second resistors or measure a signal of the bio-signal electrode, according to whether the switch block is turned on. The first reference voltage may be greater than the second reference voltage.

In an embodiment of the inventive concept, a circuit for measuring a bio-stimulating signal and a bio-signal includes a bio-stimulating signal generating circuit, a multiplexer, a connection node, a switch block, first and second serially connected resistors, and a bio-signal measuring circuit. The bio-stimulating signal generating circuit may generate a bio-stimulating signal in a bio-stimulating mode. The first and second bio-signal electrodes may output the bio-stimulating signal generated in the bio-stimulating mode and receive a bio-signal in a bio-signal measuring mode. The multiplexer may select at least one of the first and second bio-signal electrodes by a control signal and connect the selected bio-signal electrode to the bio-stimulating signal generating circuit. The connection node may allow the bio-stimulating signal generating circuit and the multiplexer to be connected thereto. The switch block may be turned on in a case where a voltage of the bio-stimulating signal is greater than a first reference voltage or lower than a second reference voltage. The first and second serially connected resistors may be connected between the connection node and the switch block and divide a voltage of a signal of the selected bio-signal electrode according to whether the switch block is turned on. The bio-signal measuring circuit may measure voltage signals divided by the first and second resistors or measure a signal of the selected bio-signal electrode, according to whether the switch block is turned on. The first reference voltage may be greater than the second reference voltage.

BRIEF DESCRIPTION OF THE FIGURES

The accompanying drawings are included to provide a further understanding of the inventive concept, and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the inventive concept and, together with the description, serve to explain principles of the inventive concept. In the drawings:

FIG. **1** is a circuit diagram that shows a bio-stimulating and bio-signal measuring circuit according to an embodiment of the present application;

FIG. **2** is a conceptual diagram that shows operations according to the voltages of first nodes of first and second switch circuits shown in FIG. **1**; and

FIGS. **3** to **7** are circuit diagrams that show bio-stimulating and bio-signal measuring circuits according to other embodiments of the present application.

DETAILED DESCRIPTION

It should be understood that the foregoing general descriptions and the following detailed descriptions are all exemplary, and it should be appreciated that the additional descriptions of the claimed invention are provided. Reference signs are shown in detail in the exemplary embodiments of the inventive concept, and their examples are shown in reference drawings. Wherever possible, the same reference numeral is used for descriptions and drawings in order to refer to the same or similar part.

In the following, a semiconductor circuit would be used as an example for describing the characteristic and function of the inventive concept. However, a person skilled in the art would be capable of easily understanding other advantages and performance of the inventive concept according to the content set forth herein. The inventive concept would also be capable of being implemented or applied through other embodiments. Moreover, the detailed description may be modified or changed according to a perspective and application without departing significantly from the scope, technical spirit and other objects of the inventive concept.

FIG. **1** is a circuit diagram that shows a bio-stimulating and bio-signal measuring circuit according to an embodiment of the present application. Referring to FIG. **1**, the bio-stimulating and bio-signal measuring circuit **100** may include a bio-stimulating signal generating circuit **110**, a bio-signal electrode **120**, first and second resistors R**1** and R**2**, first and second switch circuits **130** and **140**, and a bio-signal measuring circuit **150**.

The operation of the bio-stimulating and bio-signal measuring circuit **100** may be divided into a bio-stimulating mode and a bio-signal measuring mode. The bio-stimulating mode is a mode in which the bio-stimulating and bio-signal measuring circuit **100** stimulates a body. The bio-signal measuring mode is a mode in which the bio-stimulating and bio-signal measuring circuit **100** measures a response signal for a bio-stimulating signal or a general bio-signal from a body.

The bio-stimulating signal generating circuit **110** is connected to the bio-signal electrode **120**, the first resistor R**1**, and the first and second switch circuits **130** and **140** through the first node N**1**. The bio-stimulating signal generating circuit **110** generates a bio-stimulating signal in the bio-stimulating mode. The generated bio-stimulating signal is provided to the bio-signal electrode **120**. Also, the generated bio-stimulating signal is provided to the first and second switch circuits **130** and **140**. For example, the bio-stimulating signal may be a voltage or current signal. Thus, the bio-stimulating signal generating circuit **110** may include all circuits that may generate the voltage or current signal. For example, the bio-stimulating signal generating circuit **110** may include a digital analog converter (DAC) or function generator.

For example, the bio-stimulating signal may include at least one of transcranial Direct Current Stimulation (tDCS), transcranial Alternating Current Stimulation (tACS), or transcranial Random-Noise Stimulation (tRNS).

The bio-signal electrode **120** is connected to the bio-stimulating signal generating circuit **110**, the first resistor R**1**, and the first and second switch circuits **130** and **140** through the first node N**1**. The bio-signal electrode **120** delivers to a body the bio-stimulating signal generated by the bio-stimulating signal generating circuit **110**. Alternatively, the bio-signal electrode **120** receives the bio-signal from the body. That is, the bio-signal electrode **120** may be used for both bio-stimulating signal generation and bio-signal measurement.

For example, the bio-signal may include at least one of electroencephalogram (EEG), electrocardiogram (ECG), electromyogram (EMG), or electrooculography (EOG).

The first resistor R**1** is connected between the first node N**1** and the second node N**2**. The second resistor R**2** is connected between the second node N**2** and a third node N**3**. In the case where at least one of the first and second switch circuits **130** and **140** is turned on, the first and second resistors R**1** and R**2** may operate as voltage dividers. In this case, the first and second resistors R**1** and R**2** divide a voltage of the first node according to the proportion of values of the first resistor R**1** and the second resistor R**2** to provide the voltage to the second node N**2**.

For example, resistances of the first resistor R**1** and the second resistor R**2** may be determined so that the amount of current flowing along the first resistor R**1** is lower than an allowable amount of current of the bio-signal measuring circuit **150**. Alternatively, the resistances of the first resistor R**1** and the second resistor R**2** may be determined to be lower than the allowable amount of current of the first and second switch circuits **130** and **140**. Also, the proportion of the resistances of the first resistor R**1** and the second resistor R**2** may be defined by an allowable range of voltage of the bio-signal measuring circuit **150**. That is, the first and second resistors R**1** and R**2** are circuits for preventing the bio-signal measuring circuit **150** from becoming damaged by a bio-stimulating signal.

The first and second switch circuits **130** and **140** are connected between the third node N**3** and a first source voltage GND. The first switch circuit **130** may be set to be turned on in the case where a voltage is equal to or higher than a first reference voltage Vref**1**. The second switch circuit **140** may be set to be turned on in the case where a voltage is equal to or lower than a second reference voltage Vref**2**. In the present embodiment, the first and second switch circuits **130** and **140** are controlled by a voltage of the first node N**1**. Here, the voltage of the first node N**1** would be a bio-stimulating signal or bio-signal as described above. Thus, the first switch circuit **130** is turned on in the case where the voltage of the first node N**1** is equal to or higher than the first reference voltage Vref**1**. The second switch circuit **140** is turned on in the case where the voltage of the first node N**1** is lower than or equal to the second reference voltage Vref**2**. The first reference voltage Vref**1** is greater than the second reference voltage Vref**2**. The conditions and examples of the first and second reference voltages Vref**1** and Vref**2** would be described with reference to FIG. **2**.

For example, the first switch circuit **130** may include an NMOS transistor. In this case, the first reference voltage Vref**1** would be the threshold voltage of the NMOS transistor. Alternatively, the first switch circuit **130** may include an NPN type bipolar junction transistor (BJT). For example, the second switch circuit **140** may include a PMOS transistor. In this case, the second reference voltage Vref**2** would be the threshold voltage of the PMOS transistor. Alternatively, the second switch circuit **140** may include a PNP type BJT. The operating regions of the first and second switch circuits **130** and **140** according to the voltage of the first node N**1** would be described with reference to FIG. **2**.

FIG. **2** is a conceptual diagram that shows operations according to the voltages of first nodes of first and second switch circuits shown in FIG. **1**. Referring to FIG. **2**, it is possible to be aware of the operating states of the first and second switch circuits **130** and **140** in FIG. **1** according to a level of a bio-stimulating signal.

In the case where a voltage of the first node N**1** is greater than the first reference voltage Vref**1**, the first switch circuit **130** is turned on and the second switch circuit **140** is turned off. In the case where the voltage of the first node N**1** is a voltage level between the first reference voltage Vref**1** and the second reference voltage Vref**2**, the first and second switch circuits **130** and **140** are turned off. In the case where the voltage of the first node N**1** is lower than the second reference voltage Vref**2**, the first switch circuit **130** is turned off and the second switch circuit **140** is turned on.

The first and second switch circuits **130** and **140** are circuits for preventing the bio-signal measuring circuit **150** from becoming damaged by a bio-stimulating signal. Thus, the first and second switch circuits **130** and **140** are set to be turned on when the bio-stimulating signal is generated. On the contrary, the first and second switch circuits **130** and **140** should not operate in the case where a bio-signal is provided through the bio-signal electrode **120**. That is, the bio-signal needs not to be provided to the bio-signal measuring circuit **150** through a voltage divider. The reason is that the bio-signal is small in amplitude. Therefore, the first reference voltage Vref**1** may be set to be greater than the voltage level of the bio-signal. The second reference voltage Vref**2** may be set to be lower than the voltage level of the bio-signal.

For example, the bio-stimulating signal and the bio-signal may always have a negative voltage level. In this case, the first and second reference voltages Vref**1** and Vref**2** would be a negative voltage level. The bio-stimulating signal and the bio-signal may always have a positive voltage level. In this case, the first and second reference voltages Vref**1** and Vref**2** would be a positive voltage level. Alternatively, the bio-stimulating signal and the bio-signal may have a negative voltage level or positive voltage level. In this case, the first reference voltage Vref**1** may have a positive voltage level and the second reference voltage Vref**2** may have a negative voltage level.

Referring back to FIG. **1**, the bio-signal measuring circuit **150** is connected to the first and second resistors R**1** and R**2** through the second node N**2**. The bio-signal measuring circuit **150** measures a voltage of the second node N**2** in a bio-stimulating mode. In the bio-stimulating mode, the voltage of the second node N**2** is a voltage generated when the bio-stimulating signal is divided by a voltage divider. Also, the bio-signal measuring circuit **150** may measure the bio-signal in a bio-signal measuring mode. In this case, the first and second switch circuits **130** and **140** are not turned on according to the above-described embodiment. Thus, a voltage of the second node N**2** is the same as the voltage of the bio-signal. The bi-signal measuring circuit **150** may include all circuits that may measure the voltage or current signal. For example, the bio-signal measuring circuit **150** may include an analog digital converter (ADC), a comparator or an amplifier.

The bio-stimulating and bio-signal measuring circuit **100** in FIG. **1** is shown that each of components (the bio-stimulating signal generating circuit, the bio-signal electrode, the first and second switch circuits, or the like) include a single component. However, the present application is not limited thereto. Each component may include a plurality of components. For example, a set of the voltage divider that includes the first and second resistors R**1** and R**2**, and the first and second switch circuits **130** and **140** may be in plurality. In this case, each set may be configured to operate under the individual condition. Also, although the first and second switch circuits **130** and **140** in FIG. **1** are shown to be configured as divided circuits, it is possible to configure them as a switch block that performs the same function. The above-described switch block would be capable of being implemented in hardware.

The operation of the bio-stimulating and bio-signal measuring circuit **100** is as follows. Firstly, the bio-stimulating signal generating circuit **110** generates a bio-stimulating signal in a bio-stimulating mode. The voltage signal is delivered to a user's body through the bio-signal electrode **120**. Also, the voltage signal is delivered to the first and second switch circuits **130** and **140** through the first node N**1**. For example, the case where the voltage signal is greater than the first reference voltage Vref**1** is assumed. In this case, the first switch circuit **130** is turned on. Subsequently, the first and second resistors R**1** and R**2** operates as a voltage divider. Thus, the voltage of the first node N**1** is divided by the resistance ratio of the first and second resistors R**1** and R**2** and provided to the second node N**2**. Then, the bio-signal measuring circuit **150** measures a voltage of the second node N**2**.

Alternatively, in the case where the voltage signal of the first node N**1** is lower than the second reference voltage Vref**2**, the second switch circuit **140** is turned on. The following operation is the same above. That is, the second switch circuit **140** is turned on so that the first and second resistors R**1** and R**2** operate as a voltage divider. Subsequently, the voltage of the bio-stimulating signal is divided and provided to the second node N**2**. As described above, the voltage value of the second node N**2** would be within a range of input of the bio-signal measuring circuit **150**. Thus, damage to the bio-signal measuring circuit **150** by the bio-stimulating signal that has an excessive voltage level is prevented. The bio-signal measuring circuit **150** may measure the voltage of the second node N**2** divided by a voltage divider to monitor the actual voltage level of the bio-stimulating signal.

In a bio-signal measuring mode, the operation of the bio-stimulating and bio-signal measuring circuit **100** is as follows. The bio-signal electrode **120** receives the bio-signal from a user's body. In comparison to the bio-stimulating signal, the bio-signal has a relatively low voltage level. That is, the bio-signal is lower than the first reference voltage Vref**1** and higher than the second reference voltage Vref**2**. Thus, the first and second switch circuits **130** and **140** are not turned by the bio-signal. That is, the voltage of the bio-signal is not divided through the first and second resistors R**1** and R**2**. Subsequently, the bio-signal is provided to the bio-signal measuring circuit **150** through the first node N**1** and the first resistor R**1**. The bio-signal measuring circuit **150** measures the received bio-signal.

In summary, the bio-stimulating and bio-signal measuring circuit **100** automatically lowers the voltage level of a signal by a voltage divider in the bio-stimulating mode to prevent damage to the bio-signal measuring circuit **150**. In a bio-signal measuring mode, the bio-stimulating and bio-signal measuring circuit **100** also inactivates a voltage divider to measure the bio-signal as it is. Thus, the bio-stimulating and bio-signal measuring circuit **100** according to an embodiment of the present application may simultaneously perform bio-stimulating and bio-signal measurement by a single circuit without dividing the bio-signal electrode **120**.

FIGS. **3** to **7** are circuit diagrams that show bio-stimulating and bio-signal measuring circuits according to other embodiments of the present application.

Referring to FIG. **3**, a bio-stimulating and bio-signal measuring circuit **200** may include a bio-stimulating signal generating circuit **210**, a bio-signal electrode **220**, first and second resistors R**1** and R**2**, first and second comparators **230** and **240**, first and second voltage sources V**1** and V**2**, first and second switch circuits **250** and **260**, and a bio-signal measuring circuit **270**. Except for the first and second comparators **230** and **240** and the first and second switch circuits **250** and **260**, the bio-stimulating and bio-signal measuring circuit **200** in FIG. **3** has the same configuration and operation as the bio-stimulating and bio-signal measuring circuit **100** in FIG. **1**. Thus, related descriptions are omitted.

The first comparator **230** is connected between the first node N**1** and a node CTRL**1**. The first comparator **230** determines whether the voltage level of the first node N**1** is greater than the voltage level of the first voltage source V**1**. The first comparator **230** generates a turn-on voltage for the first switch **250** according to a result of determination. For example, the voltage level of the first voltage source V**1** may be set to be equal to the first reference voltage Vref**1** in FIG. **2**.

The second comparator **240** is connected between the first node N**1** and a node CTRL**2**. The second comparator **240** determines whether the voltage level of the first node N**1** is lower than the voltage level of the second voltage source V**2**. The second comparator **240** generates a turn-on voltage for the second switch circuit **260** according to a result of determination. For example, the voltage level of the second voltage source V**2** may be set to be equal to the second reference voltage Vref**2** in FIG. **2**.

The first and second switch circuits **130** and **140** in FIG. **1** are configured to be turned on by different reference voltages, respectively. In the case where the first switch circuit **130** is the NMOS transistor and the second switch circuit **140** is the PMOS transistor according to the above-described embodiment, the first and second reference voltages Vref**1** and Vref**2** become the threshold voltages of the NMOS transistor and the PMOS transistor, respectively. In this case, the threshold voltage may easily vary by a change in process voltage temperature (PVT). In an embodiment of FIG. **3**, the first and second switch circuits **250** and **260** may use the same circuit. That is, the first and second comparators **230** and **240** generate the same turn-on voltage for respective nodes CTRL**1** and CTRL**2** according to a result of comparison. Also, the first and second voltage sources V**1** and V**2** may be configured as an adjustable, variable voltage sources. Thus, in comparison to the bio-stimulating and bio-signal measuring circuit **100** in FIG. **1**, the bio-stimulating and bio-signal measuring circuit **200** in FIG. **3** is easy to set the voltage levels of the first and second voltage sources V**1** and V**2** to desired levels.

Referring to FIG. **4**, the bio-stimulating and bio-signal measuring circuit **300** may include a bio-stimulating signal generating circuit **310**, a bio-signal electrode **320**, first and second resistors R**1** and R**2**, first and second switch circuits **330** and **340**, a bio-signal measuring circuit **350**, and a control circuit **360**. Except for the control circuit **360**, the bio-stimulating and bio-signal measuring circuit **300** in FIG. **4** has the same configuration and operation as the bio-stimulating and bio-signal measuring circuit **100** in FIG. **1**. Thus, related descriptions are omitted.

The control circuit **360** is connected to the bio-signal measuring circuit **350** and the bio-stimulating signal generating circuit **310**. The control circuit **360** receives feedback on measurement values of a bio-stimulating signal and a bio-signal from the bio-signal measuring circuit **350**. The control circuit **360** monitors the feedback measurement value to adjust the voltage level of a bio-stimulating signal generated by the bio-stimulating signal generating circuit **310**. The reason for adjusting the voltage level of the bio-stimulating signal is that impedance varies according to the position of a user or the bio-signal electrode. In the case where bio-impedance varies, it is difficult to provide a desired waveform of the bio-stimulating signal for the same bio-stimulating signal. The control circuit **360** controls the bio-stimulating signal generating circuit **310** to provide the desired waveform of the bio-stimulating signal even when the bio-impedance varies.

For example, the control circuit **360** may include a processor, a micro processor, a micro controller, a central processing unit (CPU), a micro processing unit (MPU), a micro controlling unit (MCU) or the like.

For example, the control circuit **360** may include ADC and DAC. The ADC converts an analog signal monitored by the bio-signal measuring circuit **350** into a digital signal. The control circuit **360** generates a digital signal or code for controlling the bio-stimulating signal generating circuit **310** based on the digital signal from the ADC. The generated digital signal or code is converted into an analog signal by the DAC to control the bio-stimulating signal generating circuit **310** in real time.

As another example, the control circuit **360** may include a memory or interface circuit. The memory may store information, such as commands and programs for the operations of a bio-stimulating mode and a bio-signal measuring mode, data for bio-stimulation, and algorithms for the reading of a bio-signal. The memory may include a random access memory (RAM), a read only memory (ROM), an erasable programmable ROM (EPROM), an electrically EPROM (EEPROM), a flash memory or the like.

The interface circuit may relay the communication between a user and the control circuit **360** according to the control of the control circuit **360**. As an example, the interface circuit may include an input interface, such as a keyboard, keypad, button, touch panel, touch screen, touch pad, touch ball, camera, microphone, gyroscope sensor, or vibration sensor. Also, the interface circuit may include an output interface, such as a liquid crystal display (LCD), organic light emitting diode (OLED) display device, active matrix OLED (AMOLED) display device, LED, speaker, or monitor.

Referring to FIG. **5**, a bio-stimulating and bio-signal measuring circuit **400** may include a bio-stimulating signal generating circuit **410**, a bio-signal electrode **420**, first and second resistors R**1** and R**2**, first and second comparators **430** and **440**, first and second voltage sources V**1** and V**2**, first and second switch circuits **450** and **460**, a bio-signal measuring circuit **470**, and a control circuit **480**. Except for the control circuit **480**, the bio-stimulating and bio-signal measuring circuit **400** in FIG. **5** has the same configuration and operation as the bio-stimulating and bio-signal measuring circuit **200** in FIG. **3**. Also, the control circuit **480** in FIG. **5** has the same configuration and operation of the control circuit **360** shown in FIG. **4**. Thus, related descriptions are omitted.

Referring to FIG. **6**, the bio-stimulating and bio-signal measuring circuit **500** may include a bio-stimulating signal generating circuit **510**, first and second bio-signal electrodes **520** and **530**, first and second control switches SWC**1** and SWC**2**, first and second resistors R**1** and R**2**, first and second switch circuits **540** and **550**, a bio-signal measuring circuit **560**, and a control circuit **570**. Except for the first and second bio-signal electrodes **520** and **530** and the first and second control switches SWC**1** and SWC**2**, the bio-stimulating and bio-signal measuring circuit **500** in FIG. **6** has the same configuration and operation as the bio-stimulating and bio-signal measuring circuit **300** in FIG. **4**. Thus, related descriptions are omitted.

The first bio-signal electrode **520** is connected to the first control switch SWC**1**. The first control switch SWC**1** connects the first node N**1** to the first bio-signal electrode **520** and is controlled by the control circuit **570**. The second bio-signal electrode **530** is connected to the second control switch SWC**2**. The second control switch SWC**2** connects the first node N**1** to the second bio-signal electrode **530** and is controlled by the control circuit **570**.

The bio-stimulating and bio-signal measuring circuit **500** in FIG. **6** may insert the first and second bio-signal electrodes **520** and **530** into different parts of a user body, respectively. Then, the control circuit **570** may select one of the first and second bio-signal electrodes **520** and **530** for a desired part. For example, in the case where the first bio-signal electrode **520** is selected, the control circuit **570** closes the first control switch SWC**1** and opens the second control switch SWC**2**. Accordingly, the bio-stimulating and bio-signal measuring circuit **500** may perform stimulation and measurement on a desired one of a plurality of body parts by a single circuit.

Referring to FIG. **6**, the control switches SWC**1** and SWC**2** and the bio-signal electrodes **520** and **530** are shown as two components. However, the present application is not limited thereto. Thus, the control switches and the bio-signal electrodes may be configured as two or more components. Also, although the first and second control switches SWC**1** and SWC**2** in FIG. **6** are shown to be configured as divided circuits, it is possible to configure them as a multiplexer that performs the same function. The above-described multiplexer would be capable of being implemented in hardware.

Referring to FIG. **7**, a bio-stimulating and bio-signal measuring circuit **600** may include a bio-stimulating signal generating circuit **610**, first and second bio-signal electrodes **620** and **630**, first and second resistors R**1** and R**2**, first and second comparators **640** and **650**, first and second voltage sources V**1** and V**2**, first and second switch circuits **660** and **670**, a bio-signal measuring circuit **680**, and a control circuit **690**. Except for the first and second bio-signal electrodes **620** and **630** and the first and second control switches SWC**1** and SWC**2**, the bio-stimulating and bio-signal measuring circuit **600** in FIG. **7** has the same configuration and operation as the bio-stimulating and bio-signal measuring circuit **400** in FIG. **5**. Also, the first and second bio-signal electrodes **620** and **630** and the first and second control switches SWC**1** and SWC**2** shown in FIG. **7** have the same configurations and operations as the first and second bio-signal electrodes **520** and **530** and the first and second control switches SWC**1** and SWC**2** shown in FIG. **6**. Thus, related descriptions are omitted.

The bio-stimulating and bio-signal measuring circuits **100** to **600** according to embodiments of the present application may be mounted by using a package, such as Package on Package (PoP), ball grid array (BGA), chip scale package (CSP), plastic leaded chip carrier (PLCC), Plastic Dual In-line Package (PDIP), Die in Waffle Pack, Die in Wafer Form, chip on board (COB), Ceramic Dual In-line Package (CERDIP), metric quad flat pack (MQFP), thin quad flat pack (TQFP), small outline integrated circuit (SOIC), shrink small outline package (SSOP), thin small outline package (TSOP), system in package (SIP), multi chip package (MCP), Wafer-level Fabricated Package (WFP), or Wafer-Level Processed Stack Package (WSP).

According to an embodiment of the inventive concept, the bio-stimulating and bio-signal measuring circuit may measure a bio-stimulating signal and a bio-signal by a single bio-electrode. Thus, a size of a circuit decreases and user convenience increases. Also, the bio-stimulating and bio-signal measuring circuit may simultaneously perform bio-stimulating and bio-signal measurement. Thus, the bio-stimulating and bio-signal measuring circuit may detect and handle an abnormal signal by real-time control.

As above, best embodiments are set forth in the drawings and in the specification. Although specific terms are used herein, they are only used for the purpose of describing the inventive concept and not used to define the meaning or limit the scope of the inventive concept set forth in the following claims. Therefore, a person skilled in the art would understand that it is possible to implement various variations and other equivalent embodiments from the inventive concept.

Thus, the true technical protective scope of the inventive concept would be defined by the technical spirit of the following claims.

What is claimed is:

1. A circuit for measuring a bio-stimulating signal and a bio-signal, the circuit comprising:

a bio-stimulating signal generating circuit configured to generate the bio-stimulating signal and deliver the bio-stimulating signal to a first node when the circuit is in a bio-stimulating mode;

a bio-signal electrode coupled to the first node to:

receive the bio-stimulating signal from the first node when the circuit is in the bio-stimulating mode, and

provide the bio-signal to the first node when the circuit is in a bio-signal measuring mode;

a first resistor coupled between the first node and a second node;

a second resistor coupled between the second node and a switch block;

the switch block coupled between a ground and the second resistor and configured to turn on when a voltage of the bio-stimulating signal is greater than a first reference voltage or lower than a second reference voltage and to turn off when the voltage of the bio-stimulating signal is less than the first reference voltage and greater than the second reference voltage,

wherein the first and second resistors operate to divide a voltage of the first node to produce a voltage of the second node when the switch block is turned on; and

a bio-signal measuring circuit configured to measure the voltage of the second node,

wherein the first reference voltage is greater than the second reference voltage.

2. The circuit of claim **1**, further comprising a control circuit configured to receive feedback on a result of measurement from the bio-signal measuring circuit to adjust an intensity of the bio-stimulating signal.

3. The circuit of claim **1**, wherein the switch block comprises:

a first switch circuit configured to turn on when the bio-stimulating signal is greater than the first reference voltage; and

a second switch circuit connected in parallel to the first switch circuit, and configured to turn on when the bio-stimulating signal is lower than the second reference voltage.

4. The circuit of claim **3**, wherein the first switch circuit comprises an NMOS transistor and the second switch circuit comprises a PMOS transistor, wherein a threshold voltage of the NMOS transistor is the first reference voltage, and a threshold voltage of the PMOS transistor is the second reference voltage.

5. The circuit of claim **1**, further comprising:

a first comparator configured to determine whether the bio-stimulating signal is greater than the first reference voltage and generate a first turn-on voltage when the bio-stimulating signal is greater than the first reference voltage; and

a second comparator configured to determine whether the bio-stimulating signal is lower than the second reference voltage and generate a second turn-on voltage when the bio-stimulating signal is lower than the second reference voltage,

wherein the switch block comprises:

a first switch circuit configured to be turned on by the first turn-on voltage; and a second switch circuit connected in parallel to the first switch circuit, and configured to be turned on by the second turn-on voltage.

6. The circuit of claim **5**, further comprising a control circuit configured to receive feedback on a result of measurement from the bio-signal measuring circuit to adjust an intensity of the bio-stimulating signal.

7. The circuit of claim **1**, wherein the bio-stimulating signal comprises a transcranial Direct Current Stimulation (tDCS), a transcranial Alternating Current Stimulation (tACS), or a transcranial Random-Noise Stimulation (tRNS).

8. The circuit of claim **1**, wherein the bio-signal comprises an electroencephalogram (EEG), an electrocardiogram (ECG), an electromyogram (EMG), or an electrooculography (EOG).

* * * * *

专利名称(译)	生物刺激和生物信号测量电路		
公开(公告)号	US10390756	公开(公告)日	2019-08-27
申请号	US15/424477	申请日	2017-02-03
[标]申请(专利权)人(译)	韩国电子通信研究院		
申请(专利权)人(译)	电子通信研究院		
当前申请(专利权)人(译)	电子通信研究院		
[标]发明人	YOUM WOOSUB LEE SUNG Q HWANG GUNN		
发明人	YOUM, WOOSUB LEE, SUNG Q HWANG, GUNN		
IPC分类号	A61N1/20 A61B5/00 A61N1/36 A61B5/0476 A61B5/0402 A61B5/0488 A61B5/0496		
CPC分类号	A61B5/0402 A61B5/0476 A61B5/0488 A61B5/0496 A61B5/4836 A61N1/36025 A61N1/36031 A61N1/20 A61N1/36014		
优先权	1020160020728 2016-02-22 KR		
其他公开文献	US20170238865A1		
外部链接	Espacenet		

摘要(译)

该电路可以包括生物刺激信号生成电路，其生成生物刺激模式中的生物刺激信号，生物信号电极，其递送在生物刺激模式中生成的生物刺激信号并且接收生物信号。生物信号测量模式，当生物刺激信号的电压大于第二参考电压或低于第二参考电压的第一参考电压时导通的开关块，第一和第二电阻器生物信号测量电路，其测量由第一和第二电阻器分压的电压信号，或者根据开关块是否接通来测量生物信号电极的信号。第一和第二电阻器可以串联连接在生物信号电极和开关组之间，并且当开关组件接通时分压生物信号电极的信号的电压。