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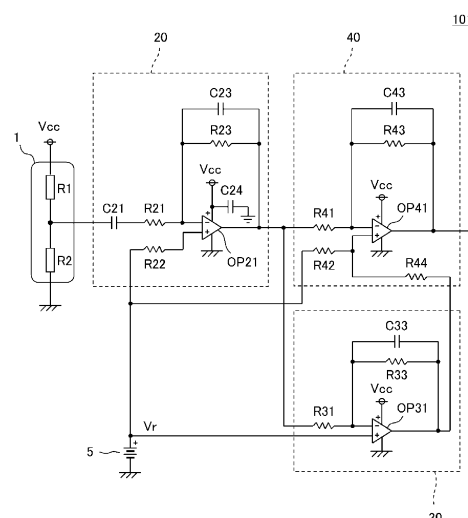
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(54) **MAGNETIC SENSING DEVICE AND BILL VALIDATOR**

(57) A magnetism detecting device that can achieve a high gain and can also detect magnetism without being affected by an offset voltage, and a banknote identifying apparatus that includes such a magnetism detecting device are configured.

A magnetism detecting device (101) includes a magnetic sensor (1) that is provided with a resistive voltage divider circuit including a magnetoresistive element (R1), an alternating current amplifier circuit (20) that subjects an output signal of the magnetic sensor (1) to alternating current amplification, an integrating circuit (30) that integrates an output signal of the alternating current amplifier circuit (20), and a differential amplifier circuit (40) that subjects the output signal of the alternating current amplifier circuit (20) and an output signal of the integrating circuit (30) to differential amplification.

FIG. 1



Description

Technical Field

[0001] The present invention relates to magnetism detecting devices that detect magnetic patterns provided in media, such as a banknote, and to banknote identifying apparatuses that identify banknotes on the basis of a magnetism detection result.

Background Art

[0002] An existing typical magnetism detecting device includes a resistive voltage divider circuit, which is a series circuit of a magnetoresistive element and a fixed resistive element, and an amplifier circuit that amplifies an output voltage of the resistive voltage divider circuit. In such a magnetism detecting device, a challenge lies in how to reduce an influence of an offset voltage of the amplifier circuit.

[0003] Patent Document 1 illustrates a magnetism detecting device that includes an integrating circuit and a differential amplifier circuit. The integrating circuit carries out processing of integrating an output voltage of a resistive voltage divider circuit, which is a series circuit of a magnetoresistive element and a fixed resistive element, so as to output an offset component signal, and the differential amplifier circuit carries out differential amplification processing of the output voltage of the resistive voltage divider circuit and the offset component signal.

Citation List

Patent Document

[0004] Patent Document 1: Japanese Unexamined Patent Application Publication No. 2010-223862

Summary of Invention

Technical Problem

[0005] In the magnetism detecting device illustrated in Patent Document 1, while the influence of the offset voltage of the amplifier circuit is reduced by canceling out the offset voltage of the amplifier circuit by the offset component signal, a high gain cannot be obtained due to the circuit configuration. Therefore, in a case in which a weak magnetism detection signal is to be handled, the number of stages of the amplifier circuits needs to be increased, which leads to a problem in that the overall circuit configuration becomes complex.

[0006] The present invention has been made in view of the above problem, and the present invention is directed to providing a magnetism detecting device that can achieve a high gain and can also detect magnetism without being affected by an offset voltage, and to a banknote

identifying apparatus that includes such a magnetism detecting device. Solution to Problem

[0007] A magnetism detecting device of the present invention includes a magnetic sensor provided with a resistive voltage divider circuit that includes a magnetoresistive element, and an amplifier circuit that amplifies an output signal of the magnetic sensor. The amplifier circuit includes an alternating current amplifier circuit that subjects the output signal of the magnetic sensor to alternating current amplification, an integrating circuit that integrates an output signal of the alternating current amplifier circuit, and a differential amplifier circuit that subjects the output signal of the alternating current amplifier circuit and an output signal of the integrating circuit to differential amplification.

[0008] Through such a configuration, a weak change in a magnetic field can be detected without being affected by an offset voltage of the amplifier circuit. Thus, a magnetic pattern or the like provided in an object to be identified can be detected with higher accuracy.

[0009] A banknote identifying apparatus of the present invention includes the above-described magnetism detecting device and a signal processing unit that recognizes information on a magnetic pattern provided in a medium on the basis of a magnetism detection result of the magnetism detecting device.

[0010] Through such a configuration, a magnetic pattern provided in a banknote can be identified with higher accuracy.

Advantageous Effects of Invention

[0011] According to the present invention, a weak change in a magnetic field can be detected without being affected by an offset voltage of the amplifier circuit, and a magnetic pattern provided in an object to be identified can be detected with higher accuracy. In addition, a magnetic pattern provided in a banknote can be identified with higher accuracy.

Brief Description of Drawings

[0012]

[Fig. 1] Fig. 1 is a circuit diagram of a magnetism detecting device 101 according to a first embodiment of the present invention.

[Fig. 2] Fig. 2(A) illustrates frequency characteristics of the gain of the magnetism detecting device 101 illustrated in Fig. 1. Fig. 2(B) illustrates frequency characteristics of the gain obtained when the capacitance value of a capacitor C21 in the magnetism detecting device 101 illustrated in Fig. 1 has been changed.

[Fig. 3] Fig. 3(A) is a waveform diagram of an input signal to an alternating current amplifier circuit 20 in the magnetism detecting device 101 illustrated in Fig. 1. Fig. 3(B) is a waveform diagram of output

signals of the alternating current amplifier circuit 20 and an integrating circuit 30 in the magnetism detecting device 101 illustrated in Fig. 1. Fig. 3(C) is a waveform diagram of an output signal of a differential amplifier circuit 40 in the magnetism detecting device 101 illustrated in Fig. 1.

[Fig. 4] Fig. 4 is a circuit configuration diagram of a banknote identifying apparatus 201 according to a second embodiment of the present invention.

[Fig. 5] Fig. 5 is a circuit diagram of a magnetism detecting device 102 according to a third embodiment of the present invention.

[Fig. 6] Fig. 6(A) is a plan view illustrating an example of a magnetic pattern provided in a medium, in which a more densely illustrated portion indicates a portion with more intense magnetism. Fig. 6(B) is a waveform diagram of an output voltage of the magnetism detecting device 102 obtained when the medium provided with the magnetic pattern illustrated in Fig. 6(A) is moved therethrough.

[Fig. 7] Fig. 7 is a circuit diagram of a magnetism detecting device according to a comparative example.

[Fig. 8] Fig. 8 is a waveform diagram of an output voltage of the magnetism detecting device according to the comparative example.

Description of Embodiments

«FIRST EMBODIMENT»

[0013] Fig. 1 is a circuit diagram of a magnetism detecting device 101 according to a first embodiment of the present invention. The magnetism detecting device 101 includes a magnetic sensor 1, an alternating current amplifier circuit 20, an integrating circuit 30, and a differential amplifier circuit 40. The magnetic sensor 1 includes a magnetoresistive element R1 and a fixed resistive element R2. The magnetoresistive element R1 and the fixed resistive element R2 form a resistive voltage divider circuit. In the magnetic sensor 1, a power supply voltage Vcc is inputted to the resistive voltage divider circuit, which is formed by the magnetoresistive element R1 and the fixed resistive element R2, and a divided voltage, serving as an output signal of the magnetic sensor 1, is outputted to the alternating current amplifier circuit 20. The alternating current amplifier circuit 20 subjects the output signal of the magnetic sensor 1 to alternating current amplification at a predetermined gain and outputs the result to the integrating circuit 30 and the differential amplifier circuit 40. The integrating circuit 30 integrates the output signal of the alternating current amplifier circuit 20 at a predetermined time constant and outputs the result to one of the input units of the differential amplifier circuit 40. The differential amplifier circuit 40 subjects the output signal of the alternating current amplifier circuit 20 and the output signal of the integrating circuit 30 to differential amplification at a predetermined gain. An output

of the differential amplifier circuit 40 serves as an output signal of the magnetism detecting device 101.

[0014] The alternating current amplifier circuit 20 includes an operational amplifier OP21. The output signal of the magnetic sensor 1 is inputted to an inverting input terminal of the operational amplifier OP21 through a capacitor C21 and a resistor R21. A parallel circuit formed by a capacitor C23 and a resistor R23 is connected between an output terminal and the inverting input terminal of the operational amplifier OP21. A reference voltage Vr outputted from a reference voltage source 5 is inputted to a non-inverting input terminal of the operational amplifier OP21 through a resistor R22. It should be noted that a capacitor C24 serving as a bypass capacitor is connected between a connection line of a power supply voltage Vcc of the operational amplifier OP21 and a ground.

[0015] The integrating circuit 30 includes an operational amplifier OP31. The output signal of the alternating current amplifier circuit 20 is inputted to an inverting input terminal of the operational amplifier OP31 through a resistor R31. A parallel circuit formed by a capacitor C33 and a resistor R33 is connected between an output terminal and the inverting input terminal of the operational amplifier OP31. The reference voltage Vr outputted from the reference voltage source 5 is inputted to a non-inverting input terminal of the operational amplifier OP31. The resistor R33 is a feedback resistor.

[0016] It should be noted that a theoretical integrating circuit does not include the resistor R33 illustrated in Fig. 1. In other words, the gain is infinite in a low frequency band. Practically, however, the gain is finite in the low frequency band of the operational amplifier OP31, and thus the resistor R33 serving as a feedback resistor is necessary. While the resistance value of the resistor R33 may be set as appropriate, as there is an influence of an offset voltage of the operational amplifier OP31, if the resistance value of the resistor R33 is set to a high value, a signal amplitude becomes larger than the dynamic range of the operational amplifier OP31 and the output signal becomes saturated. Therefore, the resistance value of the resistor R33 is set while a cutoff frequency of a high pass filter that is formed by the capacitor C33 and the resistor R33 and the offset voltage of the operational amplifier OP31 described above are taken into consideration.

[0017] The differential amplifier circuit 40 includes an operational amplifier OP41. The output signal of the alternating current amplifier circuit 20 is inputted to an inverting input terminal of the operational amplifier OP41 through a resistor R41. A parallel circuit formed by a capacitor C43 and a resistor R43 is connected between an output terminal and the inverting input terminal of the operational amplifier OP41. A resistor R42 is connected between a non-inverting input terminal of the operational amplifier OP41 and the reference voltage source 5. In addition, a resistor R44 is connected between the non-inverting input terminal of the operational amplifier OP41

and an output unit of the integrating circuit 30.

[0018] Values of the elements and voltages in the circuits illustrated Fig. 1 are, for example, as follows.

[Alternating Current Amplifier Circuit 20]

resistor R21: 10 k Ω

resistor R22: 10 k Ω

resistor R23: 1 M Ω

capacitor C21: 22 μ F

capacitor C23: 10 pF

capacitor C24: 1 μ F

[Integrating Circuit 30]

resistor R31: 10 k Ω

resistor R33: 100 k Ω

capacitor C33: 22 μ F

[Differential Amplifier Circuit 40]

resistor R41: 10 k Ω

resistor R42: 10 k Ω

resistor R43: 10 k Ω

resistor R44: 10 k Ω

capacitor C43: 1 nF

[Power Supply Voltage]

power supply voltage Vcc: 5 V

reference voltage Vr: 2 V

[0019] Fig. 2(A) illustrates frequency characteristics of the gain of the magnetism detecting device 101 illustrated in Fig. 1. Fig. 2(B) illustrates frequency characteristics of the gain obtained when the capacitance value of the capacitor C21 in the magnetism detecting device 101 illustrated in Fig. 1 has been changed, which will be described later. A characteristic curve A represents frequency characteristics between the input and the output of the alternating current amplifier circuit 20. A characteristic curve I represents frequency characteristics between the input unit of the alternating current amplifier circuit 20 (the output unit of the magnetic sensor 1) and the output unit of the integrating circuit 30, or in other words, represents combined frequency characteristics of the alternating current amplifier circuit 20 and the integrating circuit 30. A characteristic curve D represents frequency characteristics between the input unit of the alternating current amplifier circuit 20 (the output unit of the magnetic sensor 1) and the output unit of the differential amplifier circuit 40, or in other words, represents combined frequency characteristics of the alternating current amplifier circuit 20, the integrating circuit 30, and the differential amplifier circuit 40.

[0020] The gain of the alternating current amplifier circuit 20 is determined by a ratio of the resistance value of the resistor R23 to the resistance value of the resistor R21. As illustrated in Fig. 2(A), the gain of the alternating current amplifier circuit 20 is set to 100 (40 dB). The alternating current amplifier circuit 20 has band transmission characteristics, and a low pass side corner frequency (a cutoff frequency of a high pass filter) is determined by the product (time constant) of the capacitance value of the capacitor C21 and the resistance value of the re-

sistor R21. A high pass side corner frequency (a cutoff frequency of a low pass filter) is determined by the product (time constant) of the capacitance value of the capacitor C23 and the resistance value of the resistor R23.

[0021] The gain of the integrating circuit 30 is determined by a ratio of the resistance value of the resistor R33 to the resistance value of the resistor R31. As illustrated in Fig. 2(A), the gain of the integrating circuit 30 is set to 10 (20 dB). The integrating circuit 30 has low band transmission characteristics, and a corner frequency (a cutoff frequency) is determined by the product (time constant) of the capacitance value of the capacitor C33 and the capacitance value of the resistor R33.

[0022] The differential amplifier circuit 40 subjects the output signal of the alternating current amplifier circuit 20 and the output signal of the integrating circuit 30 to differential amplification, and the gain thereof is determined by a ratio of the resistance value of the resistor R43 to the resistance value of the resistor R41. It should be noted that the capacitor C43 is provided so as to remove high frequency noise.

[0023] In the example illustrated in Fig. 2(A), the resistance value of the resistor R21 is equal to the resistance value of the resistor R31, which in turn is equal to 10 k Ω , and the capacitance value of the capacitor C21 is equal to the capacitance value of the capacitor C33, which in turn is equal to 22 μ F. Thus, the time constant for determining the low pass side corner frequency of the alternating current amplifier circuit 20 matches the time constant for determining the corner frequency of the integrating circuit 30. Therefore, the frequency characteristics of the magnetism detecting device 101 as a whole are flat in a broad band ranging from 0.1 Hz to 10 kHz, as indicated by the characteristic curve D.

[0024] In the example illustrated in Fig. 2(B), the resistance value of the resistor R21 is equal to the resistance value of the resistor R31, which in turn is equal to 10 k Ω ; the capacitance value of the capacitor C21 is equal to 2.2 μ F; and the capacitance value of the capacitor C23 is equal to 22 μ F. Thus, the low pass side corner frequency of the alternating current amplifier circuit 20 does not match the corner frequency of the integrating circuit 30, and the frequency characteristics of the magnetism detecting device 101 as a whole meander as indicated by the characteristic curve D. As will be described later, when the low pass side corner frequency of the alternating current amplifier circuit 20 matches the corner frequency of the integrating circuit 30, the output voltage of the integrating circuit 30 matches the offset voltage generated in the alternating current amplifier circuit 20. Therefore, by amplifying a differential voltage between the output voltage of the alternating current amplifier circuit 20 and the output voltage of the integrating circuit 30 in the differential amplifier circuit 40, a magnetism detecting signal without an offset voltage can be obtained.

[0025] Fig. 3(A) is a waveform diagram of an input signal to the alternating current amplifier circuit 20 in the magnetism detecting device 101 illustrated in Fig. 1. Fig.

3(B) is a waveform diagram of output signals of the alternating current amplifier circuit 20 and the integrating circuit 30 in the magnetism detecting device 101 illustrated in Fig. 1. Fig. 3(C) is a waveform diagram of an output signal of the differential amplifier circuit 40 in the magnetism detecting device 101 illustrated in Fig. 1.

[0026] In the example illustrated in Fig. 3(A), the input signal to the alternating current amplifier circuit 20 is a 2 V to 2.002 V rectangular wave. In Fig. 3(B), a waveform A represents an output voltage waveform of the alternating current amplifier circuit 20, and a waveform I represents an output voltage waveform of the integrating circuit 30. While the waveform A, which is the output voltage waveform of the alternating current amplifier circuit 20, is initially a 2 V to 1.8 V rectangular wave (center voltage thereof is 1.9 V), the center voltage gradually rises due to an influence of the capacitor C21 provided at the input unit. In other words, the charging voltage of the capacitor C21 is 0 V at the beginning, and the capacitor C21 is gradually charged. Thus, the center voltage of the waveform A, which is the output voltage waveform of the alternating current amplifier circuit 20, rises as the charging of the capacitor C21 progresses, and the voltage of the inverting input terminal of the operational amplifier OP21 approaches the reference voltage V_r (2 V). In other words, the offset voltage to be superimposed on the output voltage of the alternating current amplifier circuit 20 changes gradually from 0.1 V to 0 V.

[0027] In the meantime, the waveform I, which is the output voltage waveform of the integrating circuit 30, is obtained by integrating the output voltage of the alternating current amplifier circuit 20 with the reference voltage V_r (2 V) serving as the center voltage. Thus, the output voltage waveform I of the integrating circuit 30 takes a waveform that represents a voltage corresponding to the offset voltage to be superimposed on the output voltage of the alternating current amplifier circuit 20. In other words, the stated voltage starts from 2 V and gradually approaches 2.1 V.

[0028] The differential amplifier circuit 40 subjects the output signal of the alternating current amplifier circuit 20 and the output signal of the integrating circuit 30 to differential amplification at a predetermined gain, and thus the waveform of the output signal of the differential amplifier circuit 40 becomes a 2 V to 2.2 V rectangular wave, as illustrated in Fig. 3 (C). In other words, the offset voltage generated through a change in the charging voltage of the capacitor C21 is canceled out, and thus a stable magnetism detection signal can be obtained constantly.

[0029] If the capacitor C21 at the input unit of the alternating current amplifier circuit 20 is removed to form a direct current amplifier circuit and the amplifier circuit of the magnetism detecting device is constituted only by the aforementioned direct current amplifier circuit, an offset voltage due to a capacitor is not generated. However, as the output voltage of the magnetic sensor 1 has been subjected to a direct current voltage bias, the amplifier circuit is operated so as not to exceed the dynamic range

of the amplifier circuit by the operational amplifier, and thus a high gain cannot be obtained. In addition, a temperature drift is also amplified, and thus good temperature characteristics cannot be obtained.

«SECOND EMBODIMENT»

[0030] Fig. 4 is a circuit configuration diagram of a banknote identifying apparatus 201 according to a second embodiment of the present invention. The banknote identifying apparatus 201 includes a magnetism detecting device 101A, an AD converter 31, and a signal processing unit 32. The magnetism detecting device 101A includes plurality of magnetic sensors (not illustrated) that are arrayed in columns, and the banknote identifying apparatus 201 amplifies an output of each of the magnetic sensors to thus output a magnetism detection result. The magnetism detecting device 101A includes a plural groups of the magnetism detecting devices 101 described in the first embodiment. The AD converter 31 converts an output signal of the magnetism detecting device 101A to digital data, and the signal processing unit 32 successively reads the digital data in chronological order so as to recognize information on a magnetic pattern provided in a medium.

[0031] It should be noted that in order for a plurality of magnetism detecting devices to share an AD converter, a multiplexer may be provided at an input unit of the single AD converter, and an output of each of the magnetism detecting devices may be inputted to the AD converter at time division through the multiplexer.

[0032] Through such signal processing, a unique pattern of a change in the detection signal generated while a medium provided with a magnetic pattern by a magnetic ink or the like is transported is detected; thus, the type of a banknote is determined, and the genuineness of the banknote is verified.

«THIRD EMBODIMENT»

[0033] Fig. 5 is a circuit diagram of a magnetism detecting device 102 according to a third embodiment of the present invention. The magnetism detecting device 102 includes a magnetic sensor 1, alternating current amplifier circuits 20A and 20B, integrating circuits 30A and 30B, and differential amplifier circuits 40A and 40B. The magnetism detecting device 102 is formed by connecting two stages of the circuit configuration of the magnetism detecting device 101 according to the first embodiment. It should be noted that the resistance value of a resistor R23 in the alternating current amplifier circuit 20B of the second stage is 330 k Ω , and the gain of the alternating current amplifier circuit 20B is 33. In addition, the resistance value of a resistor R43 in the differential amplifier circuit 40B of the second stage is 22 k Ω , and the gain of the differential amplifier circuit 40B is 2.2. It should be noted that, in the differential amplifier circuit 40B of the second stage, the resistance value of a resistor

R42 is 22 k Ω ; the resistance value of a resistor R44 is 33 k Ω ; and the capacitance value of a capacitor C43 is 470 pF. In addition, the differential amplifier circuit 40B of the second stage is configured such that an intermediate voltage Vo (2.5 V) is applied to an inverting input terminal of an operational amplifier OP41 through a resistor R45.

[0034] Fig. 6(A) is a plan view illustrating an example of a magnetic pattern provided in a medium, in which a more densely illustrated portion indicates a portion with more intense magnetism. Fig. 6(B) is a waveform diagram of an output voltage of the magnetism detecting device 102 obtained when the medium provided with the magnetic pattern illustrated in Fig. 6(A) is moved there-through. In Fig. 6(B), pulses occurring at times 30 ms, 50-60 ms, and 80 ms correspond to portions with steep changes in the density of the magnetic ink at the leading end, at the middle, and at the trailing end of the magnetic pattern.

[0035] In this manner, a voltage signal corresponding to the magnetism (magnetic charge) of the magnetic pattern can be outputted.

[0036] Here, as a comparative example, a magnetism detecting device of an existing technique is prepared. A circuit diagram and a waveform diagram are illustrated. Fig. 7 is a circuit diagram of a magnetism detecting device according to the comparative example. As illustrated in Fig. 7, the magnetism detecting device according to the comparative example is constituted only by the magnetic sensor 1 and the alternating current amplifier circuit 20 provided in the magnetism detecting device 101 according to the first embodiment. Fig. 8 is a waveform diagram of an output voltage of the magnetism detecting device according to the comparative example. Specifically, Fig. 8 illustrates a waveform diagram of an output voltage of the magnetism detecting device according to the comparative example obtained when a medium provided with a magnetic pattern identical to the example of the magnetic pattern illustrated in Fig. 6(A) is moved there-through.

[0037] In this manner, in a case in which the magnetism detecting device is constituted only by the magnetic sensor 1 and the alternating current amplifier circuit 20, the offset voltage varies as the capacitor C21 is charged, as indicated by arrows pointing up to the right in Fig. 8. On the other hand, according to the present invention, as illustrated in Fig. 6(B), a stable magnetism detection signal that stays free from an influence of the offset voltage can be obtained constantly.

[0038] It should be noted that the magnetoresistive element R1 is provided at a high side of the magnetic sensor 1 and the fixed resistive element R2 is provided at a low side in the example illustrated in Fig. 1 and so on. Alternatively, a fixed resistive element may be provided at a high side, and a magnetoresistive element may be provided at a low side. In addition, while the fixed resistive element may simply be a resistive element, the use of a magnetoresistive element with a small change in the re-

sistance value in response to a magnetic change as a fixed resistive element makes it possible to substantially eliminate the temperature dependence of the magnetic sensor.

Reference Signs List

[0039]

OP21, OP31, OP41 OPERATIONAL AMPLIFIERS
R1 MAGNETORESISTIVE ELEMENT
R2 FIXED RESISTIVE ELEMENT
1 MAGNETIC SENSOR
5 REFERENCE VOLTAGE SOURCE
20, 20A, 20B ALTERNATING CURRENT AMPLIFIER CIRCUITS
30, 30A, 30B INTEGRATING CIRCUITS
31 AD CONVERTER
32 SIGNAL PROCESSING UNIT
40, 40A, 40B DIFFERENTIAL AMPLIFIER CIRCUITS
101, 101A, 102 MAGNETISM DETECTING DEVICES
201 BANKNOTE IDENTIFYING APPARATUS

Claims

1. A magnetism detecting device that includes a magnetic sensor provided with a resistive voltage divider circuit that includes a magnetoresistive element, and an amplifier circuit that amplifies an output signal of the magnetic sensor, wherein the amplifier circuit includes an alternating current amplifier circuit that subjects the output signal of the magnetic sensor to alternating current amplification, an integrating circuit that integrates an output signal of the alternating current amplifier circuit, and a differential amplifier circuit that subjects the output signal of the alternating current amplifier circuit and an output signal of the integrating circuit to differential amplification.
2. A banknote identifying apparatus that includes the magnetism detecting device according to claim 1, the banknote identifying apparatus comprising:

a signal processing unit that recognizes information on a magnetic pattern provided in a medium on the basis of a magnetism detection result of the magnetism detecting device.

FIG. 1

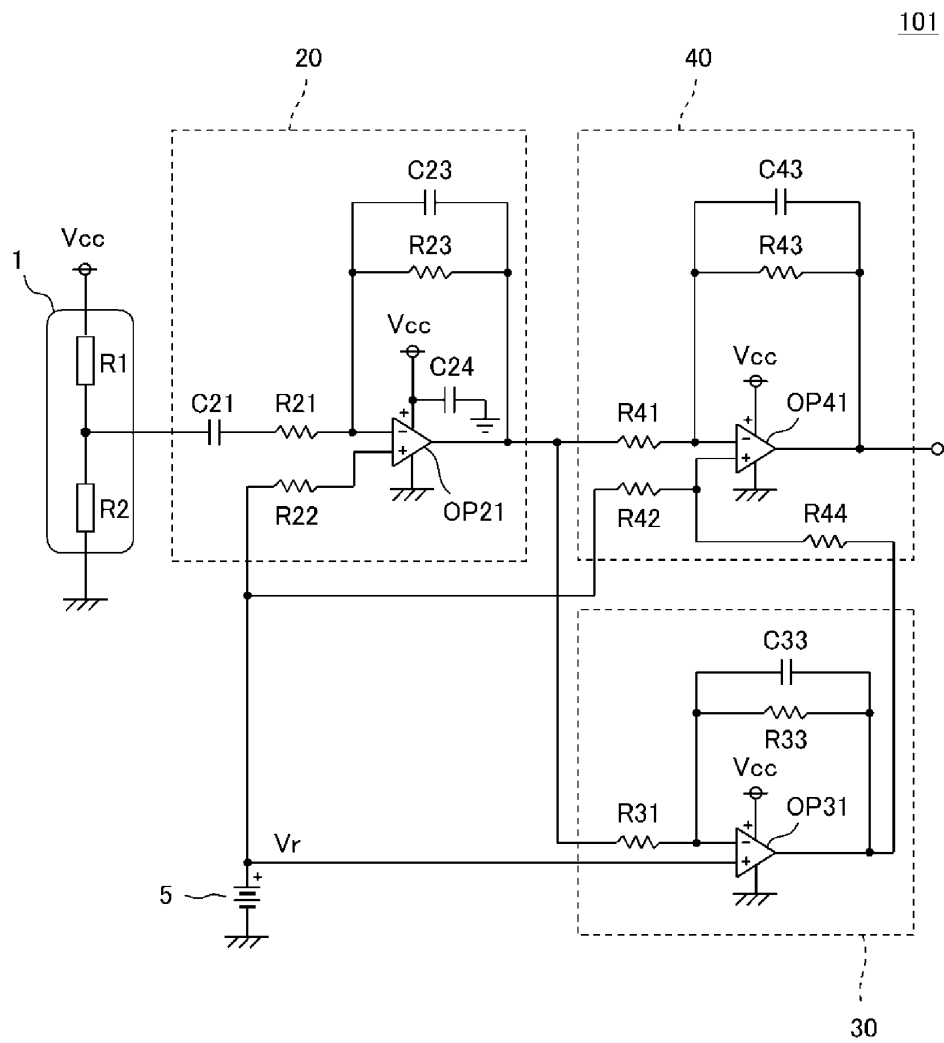


FIG. 2

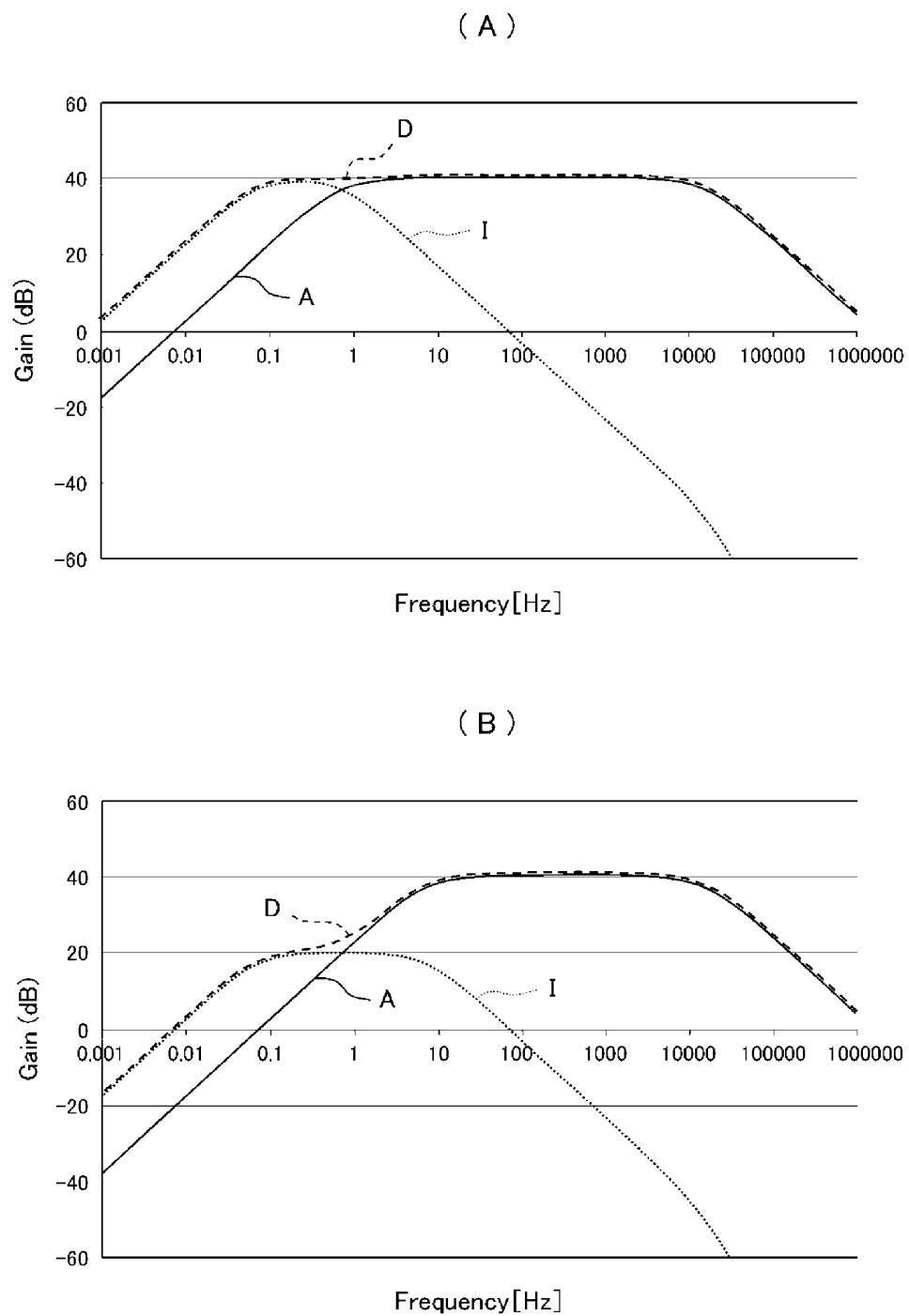


FIG. 3

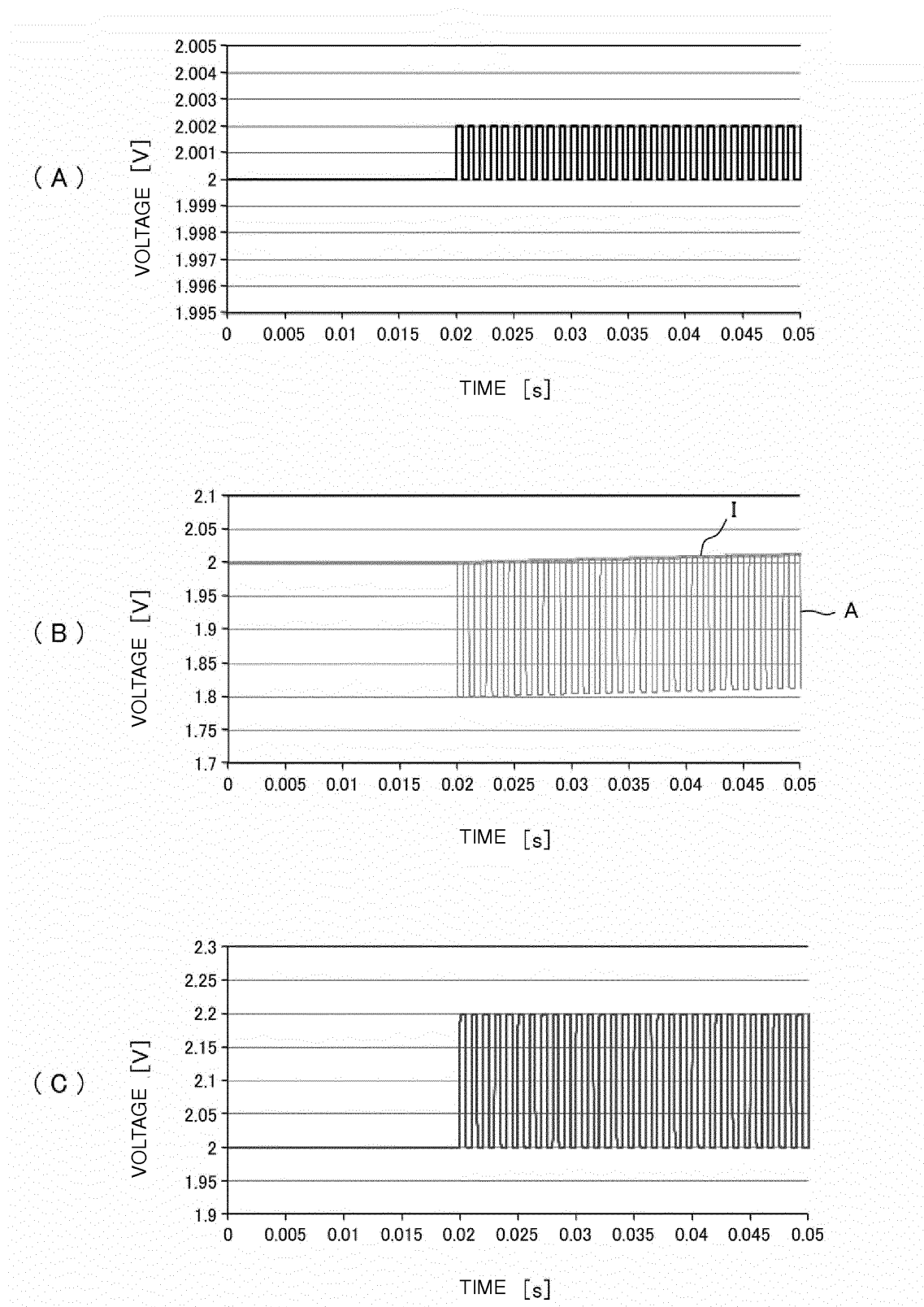


FIG. 4

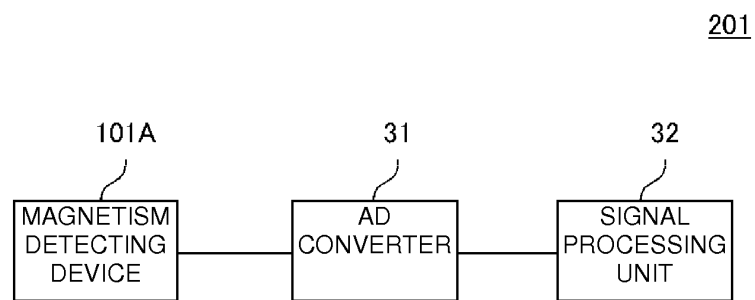


FIG. 5

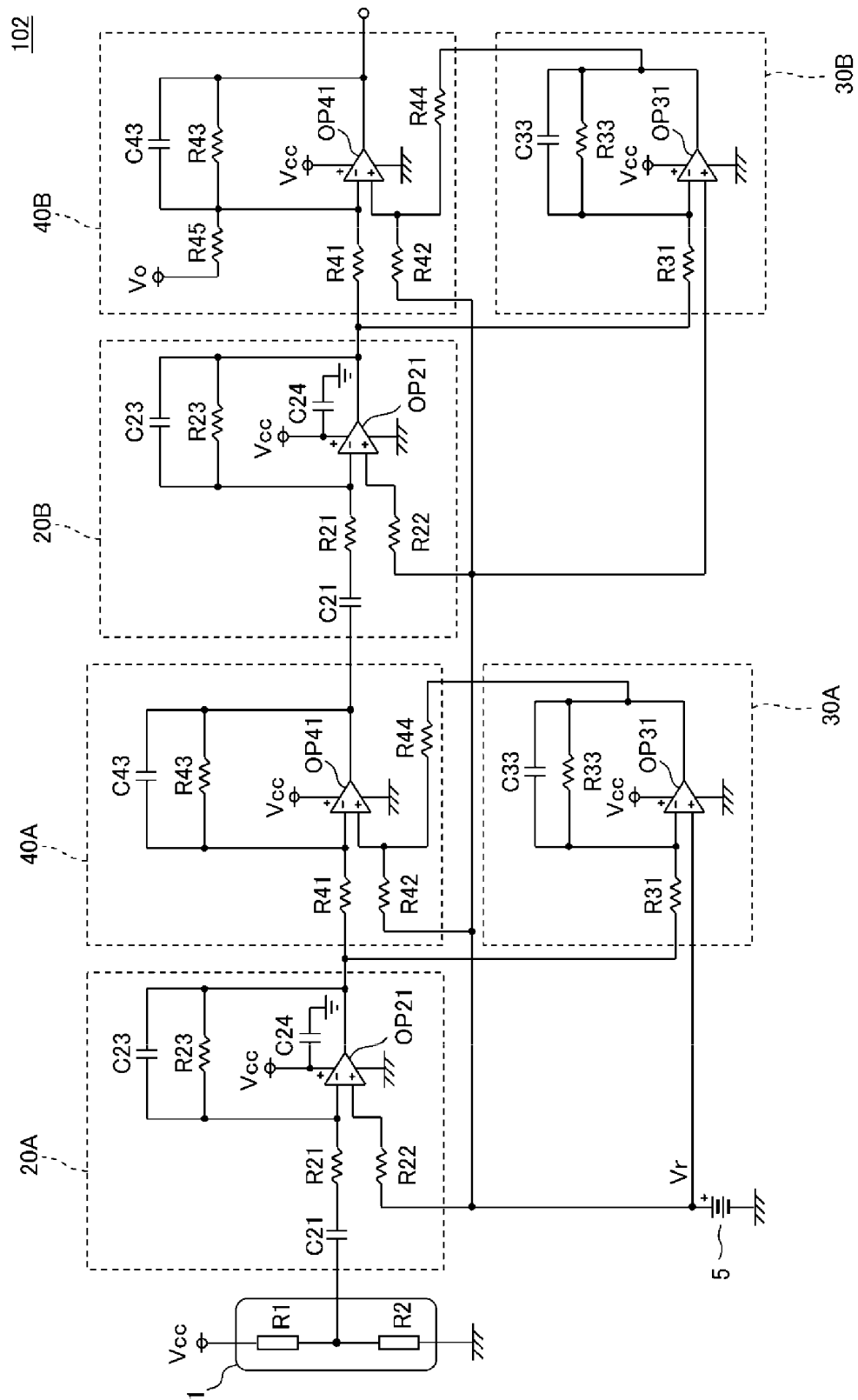


FIG. 6

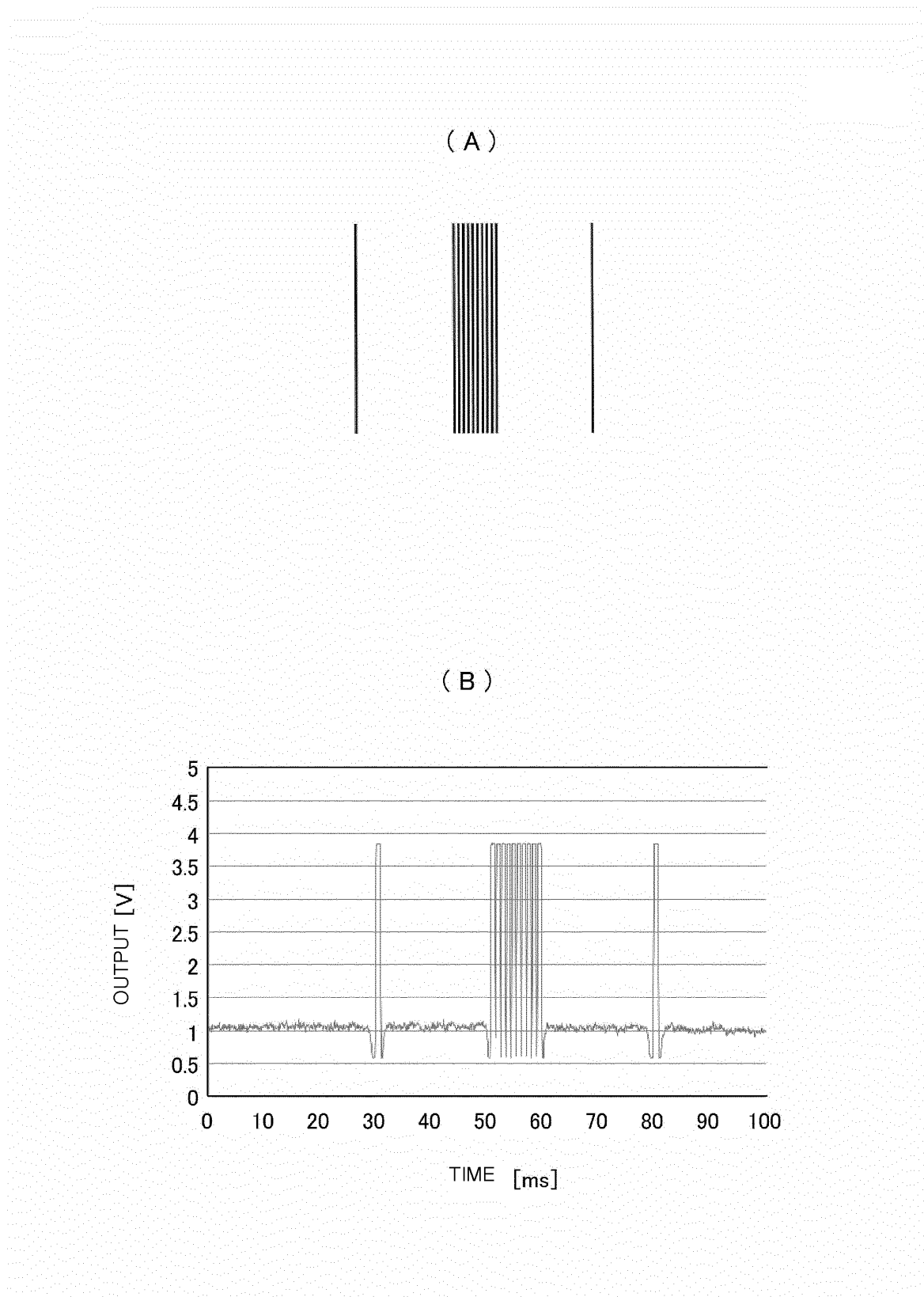


FIG. 7

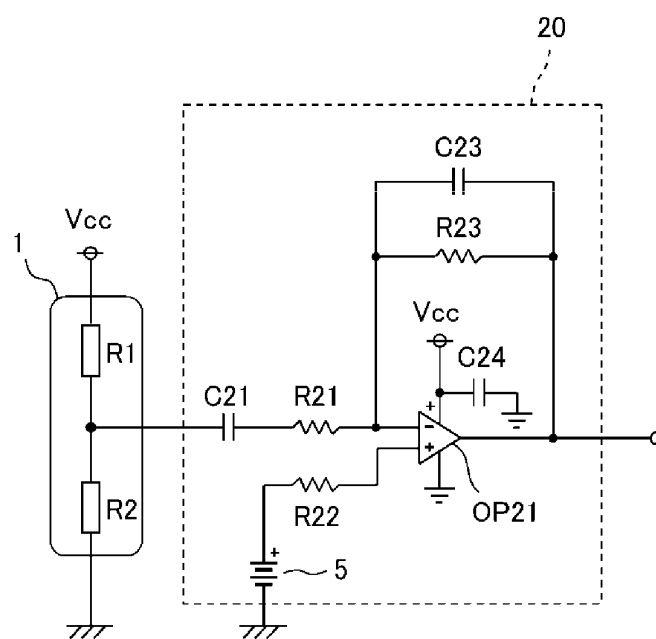
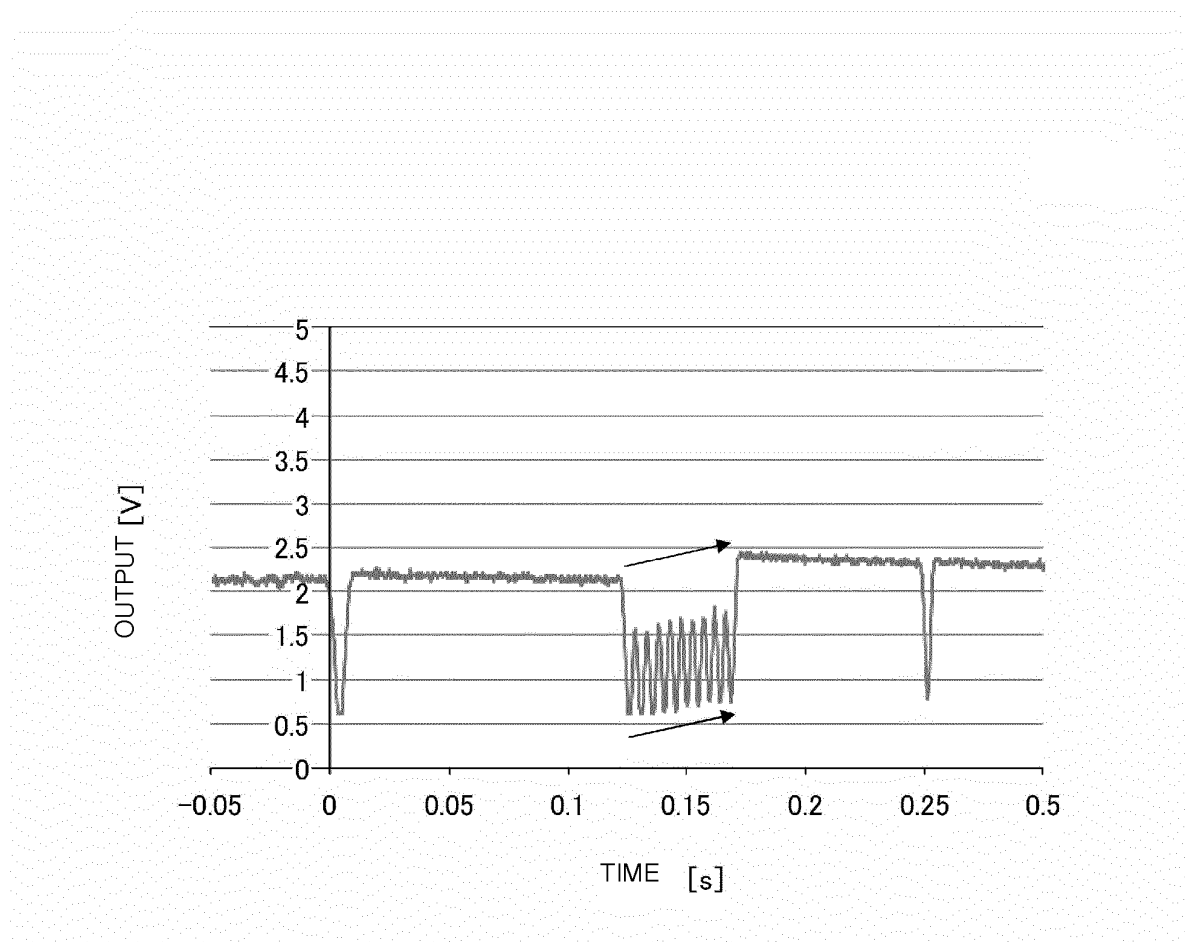


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/058001

A. CLASSIFICATION OF SUBJECT MATTER

G01R33/09(2006.01) i

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)

G01R33/09

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2010-223862 A (Murata Mfg. Co., Ltd.),	1
Y	07 October 2010 (07.10.2010), paragraphs [0023] to [0041], [0093] to [0094]; fig. 1, 8 & WO 2012/144136 A1	2
Y	WO 2012/015012 A1 (Mitsubishi Electric Corp.), 02 February 2012 (02.02.2012), paragraphs [0018] to [0049]; fig. 1 to 10 & KR 10-2013-0018984 A & JP 2012-122983 A & CN 103003711 A	2

☒ 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

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Date of the actual completion of the international search
19 June, 2013 (19.06.13)Date of mailing of the international search report
02 July, 2013 (02.07.13)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/058001

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 036634/1980 (Laid-open No. 138306/1981) (Nippondenso Co., Ltd.), 20 October 1981 (20.10.1981), specification, page 2, line 5 to page 3, line 4; fig. 1, 3 (Family: none)	1-2

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/058001

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Document 1 (JP 2010-223862 A (Murata Mfg. Co., Ltd.), 07 October 2010 (07.10.2010), paragraphs [0023] to [0041], [0093] to [0094]; fig. 1, 8 & WO 2012/144136 A1) discloses the invention relating to a magnetism detection device comprising "a magnetic-field change detection unit 10" (a magnetic sensor), "an integrator unit 20" in a first stage and "a differential amplifier unit 30" (an alternating current amplifier circuit) in the first stage, "an integrator unit 20" (an integrator circuit) in a second stage, and "a differential amplifier unit 30" (a differential current amplifier circuit) in the second stage".
(Continued to extra sheet)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/058001

Continuation of Box No.III of continuation of first sheet (2)

Therefore, the invention of claim 1 cannot be considered to be novel in the light of the invention disclosed in the document 1, and does not have a special technical feature.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2010223862 A [0004]