(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 229 006 B2

(12) # NEW EUROPEAN PATENT SPECIFICATION

After opposition procedure

(45) Date of publication and mention of the opposition decision:
27.02.2019 Bulletin 2019/09

(45) Mention of the grant of the patent:
20.11.2013 Bulletin 2013/47

(21) Application number: **08703062.3**

(22) Date of filing: **10.01.2008**

(51) Int Cl.:
H04R 3/00 *(2006.01)* ***H04R 29/00*** *(2006.01)*

(86) International application number:
PCT/JP2008/050198

(87) International publication number:
WO 2009/087772 (16.07.2009 Gazette 2009/29)

(54) **Speaker line inspection device**

Lautsprecherleitungs-Inspektionseinrichtung

Dispositif d'inspection de ligne de haut-parleur

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR

(43) Date of publication of application:
15.09.2010 Bulletin 2010/37

(60) Divisional application:
13151672.6 / 2 584 792

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(56) References cited:
JP-A- 9 218 233
JP-A- 2005 241 349
JP-A- 2007 033 288
JP-A- 2007 037 024
JP-A- 2007 037 024

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Description

[0001] This invention relates to a public address systems having a loudspeaker line examination system for examining whether there are any problems such as line breakage or short-circuiting in loudspeaker lines in a public address system built in a building or the like.

[0002] An example of prior examination systems of the above-described type is disclosed in Patent Literature 1. In a public address system according to Patent Literature 1, a plurality of loudspeakers are connected to a loudspeaker line in parallel with each other, and a power amplifier is connected to the loudspeaker line. An audio signal and a test signal are combined in a stage preceding a power amplifier, and the power amplifier amplifies the resultant composite signal and applies it to the loudspeaker line. The test signal is a signal at a constant voltage. A detecting circuit is disposed in the output of the power amplifier, which includes a filter deriving test signal current flowing to respective loudspeakers through the loudspeaker line. Since the voltage of the test signal is constant, an output signal of the filter represents a composite impedance of the loudspeaker line and the respective loudspeakers. In the loudspeaker line examination system disclosed in Patent Literature 1, the value of the output signal of the filter is compared with a threshold value for use in detecting line breakage and a threshold value for use in detecting short-circuiting, to judge whether line breakage or short-circuiting has occurred. The examination system uses, as a reference value, the value of the filter output signal developed when the loudspeaker line operates properly, and uses a value resulting from adding a first predetermined value to the reference value as the line breakage detection threshold value, and a value resulting from subtracting a second predetermined value from the reference value as the short-circuiting detection threshold value.

[0003] Patent Literature 1: JP 2007-37024 A

[0004] As described, the background art examination system determines the two threshold values, using the value of the output signal of the filter developed when the loudspeaker line is in the proper operating state, and, therefore, in order to detect line breakage and short-circuiting with high accuracy, these threshold values must be set accurately. However, sometimes there is a large difference between the output signal value measured by the described examination system for determination of the threshold values, and the output signal value measured thereafter in the normal operating state in which there is no loudspeaker line breakage or short-circuiting occurred. For example, there may be a difference between the output signal value measured when only the test signal is supplied to the loudspeaker line, and the output signal value measured in the normal use of the public address system in which the audio signal at various frequencies and the test signal are supplied to the loudspeaker. The difference in value is significant when the level of the audio signal is larger than the level of the test signal. Accordingly, the examination system of the background art may make an erroneous judgment as if there were line breakage or short-circuiting, while the loudspeaker line is in the proper operating conditions, which erroneous judgment is caused by accurate setting of the first and second values.

[0005] An object of the present invention, therefore, is to provide an examination system which can make accurate detection of line breakage or impedance decrease in a loudspeaker line, with such erroneous judgment minimized as much as possible.

[0006] According to the present invention there is provided a public address system as defined in claim 1.

[0007] The test signal may be an analog signal, or an analog signal resulting from converting a digital signal by a digital-to-analog converter. The test signal is combined with the audio signal in a combiner, and the resultant composite is supplied to the amplifier. Thus, the amplified audio and test signals are supplied to the respective loudspeakers through the loudspeaker line. Impedance determining means derives the test signal component contained in the output signal of the amplifier and determines the impedance viewed from the output of the amplifier toward the respective loudspeakers, based on the derived test signal component. For example, the impedance determining means can determine one or more impedances by deriving a voltage and current of the test signal contained in the amplifier output. Alternatively, the impedance determining means may perform frequency analysis of the amplifier output as described later, to derive a frequency component of the test signal, to thereby determine one or more impedances corresponding to the frequency of the test signal. Judging means compares the impedance determined by the impedance determining means with a predetermined threshold value and judges the presence of at least one of line breakage and impedance decrease in the loudspeaker line. For example, when the line breakage detection threshold value is used, it is judged that line breakage of the loudspeaker line or inadequate connection of some loudspeaker has occurred if the measured impedance is larger than the line breakage threshold value. When the impedance decrease detection threshold value is used, it is judged that impedance decrease has occurred in the loudspeaker line if the determined impedance is lower than the impedance decrease detection threshold value. It can be arranged that both the line breakage detection threshold value and the impedance decrease detection threshold value may be prepared so as to enable judgment of both. When the ratio of the resultant composite signal to the test signal is larger than a predetermined value, and the resultant composite signal is increasing, threshold revising means revises the threshold value in the direction to lower the degree of accuracy of judgment made in the judging means. The threshold value is set based on the impedance measured, while only the test signal is being supplied from the amplifier to the loudspeaker line.

[0008] The ratio of the composite signal to the test signal being large means that the proportion of the audio signal in the composite signal is large, and that the impedances of the loudspeaker line and the loudspeakers are under the influence of the audio signal. Therefore, erroneous judgment may result if the current threshold value is used, which is the reason why the threshold value is revised.

[0009] When the tendency of the composite signal to increase changes to the tendency to decrease, the threshold revising means may raise the degree of judgment accuracy which was lowered when the composite signal was increasing. In this case, the rate of change in the direction to lower the judgment accuracy is larger, and the rate of change in the direction to raise the judgment accuracy is smaller.

[0010] When the impedance of the loudspeaker line and the loudspeakers changes due to, for example, increase of the level of the audio signal, some time period may be necessary for the impedance to return to the original level from the level to which they changed, even when the level of the audio signal decreases. In order to cope with such situation, a smaller rate of change in the direction to raise the degree of judgment accuracy is employed.

[0011] A loudspeaker line examination system according to an example which does not fall in the scope of protection is also installed in a public address system of the same arrangement as the one described with reference to the previous embodiment. The examination system includes a test signal source, too, but the test signal contains both frequencies near the lowest and highest frequencies of the human audio frequency band. The test signal is combined with the audio signal in a combiner, and the resultant composite signal is supplied to the amplifier. The impedance determining means derives the two frequency components of the test signal contained in the output signal of the amplifier, and determines, based on the derived frequency components, the impedance viewed from the output of the amplifier toward the loudspeakers. This impedance determining means is similar to the impedance determining means described with respect to the previous embodiment. Judging means compares the determined impedance with a predetermined threshold value and judges that the loudspeaker line and the loudspeakers have been open-circuited and/or that the impedance has decreased.

[0012] Since the test signal contains different frequency components, and the impedances are determined based on these two frequency components, with these impedances being compared with the threshold value, it is possible to judge, with a higher degree of accuracy, at least one of open-circuiting of the loudspeaker line and the loudspeakers and impedance decrease.

[0013] In the above-described embodiment and example, the impedance determining means may determine the impedance in a time period during which the audio signal source stops operating. In such case, threshold setting means sets the threshold value based on the determined impedance. Second judging means judges whether the determined impedance is within a predetermined allowable range.

[0014] The impedances of the loudspeaker line and loudspeakers change with time. Accordingly, if the threshold value set on the basis of the impedances of the loudspeaker line and loudspeakers determined at a certain time is continuously used, a difference may be arisen between the actual impedances of the loudspeaker line and loudspeakers and the impedance of the loudspeaker line and loudspeakers determined for use in determining the threshold value. Therefore the impedance of the loudspeaker line and loudspeakers is determined during a time period during which no audio signal is supplied, and the threshold value is set on the basis of the thus determined impedance, in order to avoid erroneous judgment. Furthermore, by using the second judging means to judge whether the thus determined impedance Z is within the allowable range or not, it is possible to know when the loudspeakers should be replaced.

[0015] In the above-described embodiment and example, the impedance determining means may include current detecting mean for detecting current flowing through the loudspeaker line, and voltage detecting means for detecting a voltage applied to the loudspeaker line. In such case, frequency component detecting means detects the frequency components of the test signal contained in the detected current and in the detected voltage. The detection of the frequency components may be done by the cross-spectrum analysis of the detected current and voltage, for example. Operating means computes the impedance from the detected test signal frequency components.

[0016] Since the impedance of the loudspeaker line and loudspeakers is measured based on the test signal components as described above, the impedance of the loudspeaker line and loudspeakers can be measured without being affected by the audio signal.

[0017] In order that the invention may be well understood, the will now be described some embodiments thereof given by way of example, reference being made to the accompanying drawings, in which:

FIGURE 1 is a block diagram of a public address system with a loudspeaker examination system according to a first embodiment of the invention.

FIGURE 2 is a flow chart of frequency analyzing processing performed by a DSP of the examination system of FIGURE 1.

FIGURE 3 is a flow chart of root-mean-square value measuring processing performed by the DSP of the examination system of FIGURE 1.

FIGURE 4 is a flow chart of short-circuiting, line breakage and impedance increase judging processing performed by the DSP of the examination system of FIGURE 1.

FIGURE 5 is a flow chart of threshold revising processing performed by the DSP of the examination system of FIGURE 1.

FIGURE 6 is a detailed flow chart of Zopen and Zinc revising processing in the threshold revising processing of FIGURE 5.

FIGURE 7 is an illustration of change a degree of measurement accuracy Ra as revised according to the processing of FIGURE 6.

FIGURE 8 is a detailed flow chart of Z1open and Z1inc computation in the Zopen and Zinc revising processing of FIGURE 6.

FIGURE 9 is a flow chart of aging judging processing performed by the DSP of the examination system of FIGURE 1.

Best Mode for Carrying out the Invention

[0018] An examination system according to one embodiment of the present invention is embodied in a public address system like the one shown in FIGURE 1. The public address system is a system for announcing in various places in, for example, a large-scale store. The public address system includes a signal source 2 providing an audio signal. The signal source 2 may be, for example, a sound source for providing background music over the store, or a microphone through which information about the store and emergency announcement is given. The audio signal from the signal source 2 is applied through a notch filter 3 to an amplifier, e.g. a power amplifier 4, where the audio signal is amplified, and applied to a plurality of loudspeakers 8 through a loudspeaker line 6 connected to the output of the power amplifier 4. The notch filter 3 is used to attenuate those frequency components of the audio signal which are the same as frequency components of a later-described test signal for the purpose of avoiding interference with the test signal. Accordingly, a circuit arrangement may be employed in which the audio signal is inputted to the amplifier through the notch filter 3 only when the test signal is being outputted, and is inputted to the amplifier without passing through the notch filter 3 while the test signal is not being outputted. In place of the notch filter 3, a low-pass filter and/or a high-pass filter may be used. The loudspeakers are disposed at various locations in the store. In FIGURE 1, although only one loudspeaker line 6 is shown, the loudspeaker line 6 is actually composed of a pair of lines. The loudspeakers 8 are actually connected between the pair of loudspeaker lines 6 in parallel with each other.

[0019] The examination system includes a DSP (digital signal processor) 10 functioning as a signal source of the test signal at an inaudible frequency. The DSP 10 provides a digital test signal as the test signal. The digital test signal is converted to an analog test signal in a D/A (digital-to-analog) converter 12. The analog test signal and the audio signal from the signal source 2 are combined in a combiner 13. The resultant composite signal from the combiner 13 is applied to the power amplifier 4. The analog test signal is a signal containing two frequency components at, for example, 40 Hz and 20 KHz, and has a constant voltage value. Generally, the human audio frequency band is from 20 Hz to 20 KHz. The loudspeakers 8 are so designed as to give optimum sound in this human audio frequency band. The test signal is used for the purpose of measuring a composite impedance of the loudspeaker line and loudspeakers 8 connected in parallel to the loudspeaker line. Accordingly, although the frequency of the test signal desirably is within the audio frequency band, it is not desirable for the test signal components in the resultant signal, which results from combining the test signal with the audio signal, to be delivered as noise to human ears. Then, it is desirable to use, as the frequency of the test signal, either one or both of a frequency near the lowest frequency or a frequency near the highest frequency within the audio frequency band which is or are hard for human ears to sense. The loudspeakers 8 are supplied with the audio signal and the test signal as amplified in the power amplifier 4. The test signal is continuously supplied to the combiner 13 from the D/A converter 12. The audio signal is not supplied to the combiner 13 when it is not required. Alternatively, the audio signal from the signal source 2 may be A/D (analog-to-digital) converted before being combined with the test signal. In such case, the resultant composite signal is applied to the D/A converter 12.

[0020] A current detecting circuit 14 is connected in series in the output of the power amplifier 4. The current detecting circuit 14 detects the output current supplied from the power amplifier 4 to the loudspeaker line 6. Also, a voltage detecting circuit 16 is disposed in parallel in the output of the power amplifier 4. The voltage detecting circuit 16 detects the output voltage applied from the power amplifier 4 to the loudspeaker line 6.

[0021] The output signal of the current detecting circuit 14 and the output signal of the voltage detecting circuit 16 are digitized in A/D converters 18 and 20, respectively, before being applied to the DSP 10. Hereinafter, the digitized version of the output signal of the current detecting circuit 14 is referred to as a digital current detection signal, and the digitized version of the output signal of the voltage detecting circuit 16 is referred to as a digital voltage detection signal.

[0022] The DSP 10 processes the digital current detection signal, the digital voltage detection signal and the digital test signal, and judges whether the respective loudspeakers 8 and the loudspeaker line 6 are broken or short-circuited, or whether the impedance of the loudspeakers 8 and the loudspeaker line 6 have significantly decreased. The result of judgment is notified by a notification device 28. The notification device may be, for example, a display device, on which the result of judgment is displayed.

[0023] In the DSP 10, each time the successively supplied digital current detection and digital voltage detection signals are inputted to the DSP 10, the frequency analyzing processing shown in FIGURE 2 is performed.

[0024] In the frequency analyzing processing, noise frequency components are first removed from the digital current detection and digital voltage detection signals in a band-pass filter (Step S2). Then, the digital current detection and digital voltage detection signals from which noise frequency components have been removed are averaged (Step S4). Specifically, the DSP 10 is provided therein with memories equal in number to the digital current detection and digital voltage detection signals in one cycle of the test signal, and each time the digital current detection and digital voltage detection signals are supplied to the DSP 10 from the band-pass filter, they are stored in the corresponding memories over a plurality of cycles. The stored values in the memories are divided by the number of the plural cycles. The thus averaged digital current detection and digital voltage detection signals are subjected to cross-spectrum analysis to determine the correlation between the test signals contained in the digital current detection and digital voltage detection signals, and an impedance Z1 at the frequency of 20 KHz, an impedance Z2 at the frequency of 40 Hz, and the coherence of the digital current detection and digital voltage detection signals in the test signal are computed (Step S6). It should be noted that when the DSP 10 has high processing ability, Steps S2 and S4 may be skipped, and only the cross-spectrum analysis in Step S6 is sufficient.

[0025] If it is determined from the coherence that there are many frequency components other than the test signal frequency components, the DSP 10 raises the voltage of the constant-voltage test signal.

[0026] Subsequent to the processing shown in FIGURE 2, the root-mean-square values Vrms and Irms of the digital voltage detection and digital current detection signals are computed as shown in FIGURE 3 (Step S8).

[0027] Next, as shown in FIGURE 4, using the impedances Z1 and Z2 obtained, by the above-described cross-spectrum analysis and the root-mean-square value Irms of the digital current detection signal, judgment is made as to whether any one of short-circuiting, decrease in impedance (increase of output current of the power amplifier 4) and open-circuiting has occurred in the loudspeaker line 6 and the loudspeakers 8.

[0028] First, judgment is made as to whether the root-mean-square value Irms of the digital current detection signal is larger than a predetermined threshold value, e.g. a short-circuiting current value Isl of the loudspeaker line, or whether the measured impedance Z1 is smaller than a predetermined threshold value, e.g. a short-circuiting impedance Z1sl at 20 KHz of the loudspeaker line 6 and the loudspeakers 8, and, at the same time, the measured impedance Z2 is larger than a predetermined threshold value, e.g. a short-circuiting impedance Z2sl at 40 Hz of the loudspeaker line 6 and the loudspeakers 8 (Step S14). The short-circuiting current Isl and the short-circuiting impedances Z1sl and Z2sl are pre-determined in view of the protection of the loudspeaker line 6 and the loudspeakers 8. If the answer to the query in Step S14 is YES, from which it is judged that there is short-circuiting in the loudspeaker line 6 etc., such short-circuiting is indicated on the display device (Step S16), and this judgment processing is ended.

[0029] When the answer to the query in Step S14 is NO, judgment is made as to whether the measured impedance Z1 is smaller than the lower limit value Z1 inc for 20 KHz or whether the impedance Z2 is smaller than the lower limit value Z2inc for 40 Hz (Step S18). The lower limit values Z1inc and Z2inc are explained later. When the answer to the query in Step S18 is YES, which means that, while the loudspeaker line current has not yet increased to the value indicating short-circuiting, the output current from the power amplifier 4 has increased to some extent and requires some caution, current increase is displayed (Step S20), and this judgment is ended.

[0030] If the answer to the query in Step S18 is NO, judgment is made as to whether the measured impedance Z1 is larger than the upper limit value Z1open for 20 KHz or whether the impedance Z2 is larger than the upper limit value Z2open for 40 Hz (Step S22). The upper limit values Z1open and Z2open are explained later. When the answer to the query in Step S22 is YES, from which it is judged that open-circuiting has happened in the loudspeaker line 6 and the loudspeakers 8, open-circuiting is displayed (Step S24), and this judgment is ended.

[0031] In making the above-described judgments, the upper limit values Z1open and Z2open and the lower limit values Z1inc and Z2inc are used. These values are determined, based on a reference impedance Z1 ave at 20 KHz and a reference impedance Z2ave at 40 Hz of the loudspeaker line 6 and loudspeakers 8, respectively. The reference impedances Z1 ave and Z2ave are set by a worker when the worker initializes the public address system on the first use after its installation, or are set by the worker when the public address system is re-initialized for some reason. Sometimes, however, it may happen that there are large differences between these reference impedances Z1 ave and Z2ave and the impedances Z1 and Z2 measured afterwards in a normal condition where there is no line breakage or short-circuiting in the loudspeaker line 6 and loudspeakers 8. For example, if the impedances Z1 and Z2 are measured during the usual operation of the public address system, with an audio signal having various frequencies and the test signal being supplied to the loudspeaker line 6, there is a possibility that the measured impedance Z1 is different from the reference impedance Z1 ave and the impedance Z2 is different from the reference impedance Z2ave. The differences in value are significant particularly when the level of the audio signal is larger than that of the test signal. Then, as shown in FIGURE 5, after the above-described judgment is done, the upper limit values Z1open and Z2open and the lower limit values Z1 inc and Z2inc, which are prepared based on the reference impedances Z1ave and Z2ave, are subjected to revising processing.

[0032] In the revising processing, judgment is first made as to whether the root-mean-square value Vrms of the digital voltage detection signal is larger, by a predetermined factor, e.g. 1.2, or more, than the root-mean-square voltage value Vtest of the digital test signal (Step S26). If the answer is YES, it is judged that many components at the same frequencies as the test signal are contained in the audio signal. Then, the computation processing for revising the upper limit values Z1open and Z2open and the lower limit values Z1 inc and Z2inc is executed (Step S28). It should be noted that the predetermined factor is not limited to 1.2.

[0033] In the revising computation processing in Step S28, a degree of measurement accuracy Ra of the measured impedances Z1 and Z2 is used. The unit of the degree of measurement accuracy Ra is percent (%). The smaller the value, the degree of measurement accuracy of the impedance Z1, Z2 is higher, and the larger the value, the degree of measurement accuracy Ra of the impedance Z1, Z2 is lower. The degree of measurement accuracy Ra is set to the smallest value, for example, 5 %, when Vrms is equal to Vtest. As shown in FIGURE 6, judgment is made, in the revision computation processing in Step S28, as to whether the digital voltage detection signal Vrms is larger than the digital voltage detection signal ΔVrms used in the previous revision computation processing (Step S30). When the answer to the query made in Step S30 is YES, which means that audio signal components, except the test signal, at the same frequencies as the test signal, have increased from the previous revision computation processing, the value of the degree of measurement accuracy Ra must be revised to a great extent. For that purpose, computation,

$$Ra = \beta Ra + \alpha f(Vrms/Vtest),$$

is carried out. In this equation, α and β are predetermined factors, and there are relationship between α and β, that $\alpha + \beta = 1$ and $\alpha > \beta$. The function f(Vrms/Vtest) is a function with an argument Vrms/Vtest, and its value increases when the value of Vrms/Vtest is increasing and decreases when the value of Vrms/Vtest is decreasing. Thus, since the value of Vrms/Vtest is changing greatly and $\alpha > \beta$, the proportion of αf(Vrms/Vtest) in the revised degree of measurement accuracy Ra is large, and, the revised degree of measurement accuracy Ra increases rapidly when the value of Vrms/Vtest is increasing, as shown in the first half portion of FIGURE 7.

[0034] When the answer to the query made in Step S30 is NO, which means that audio signal components at the same frequencies as the test signal, except the test signal, present when the previous revision was performed, have decreased, the degree of measurement accuracy Ra is revised to have a smaller value. The rate of change in the decreasing direction, however, is smaller. For that purpose, a computation,

$$Ra = \alpha Ra + \beta f(Vrms/Vtest)$$

is performed. Since the value of Vrms/Vtest is smaller, f(Vrms/Vtest) is also smaller. Since f(Vrms/Vtest) is multiplied by β, which is smaller than α, the proportion of βf(Vrms/Vtest) in the revised Ra is small, and the value of the revised Ra gradually decreases when the value of Vrms/Vtest is decreasing, as is seen in the latter half portion of FIGURE 7.

[0035] Using the thus revised degree of measurement accuracy Ra, the computations of Z1open, Z2open, Z1inc and Z2inc are performed (Step S36). For use in the next execution of Step S30, Vrms is memorized as ΔVrms (Step S38).

[0036] The computation of Z1open and Z1inc in Step S36 is done in the manner shown in FIGURE 8. First, judgment is made as to whether the degree of measurement accuracy Ra is larger than an impedance open-circuiting proportion initial value Rul (Step S40). The impedance open-circuiting proportion initial value Rul is expressed in percent (%), and is a proportion of the upper limit impedance to the reference impedance (Z1ave, Z2ave).The upper limit impedance is the impedance at which the loudspeaker line 6 etc. can be considered to have been open-circuited, with the degree of measurement accuracy Ra being highest, or, in other words, with Ra having the smallest value. The impedance open-circuiting proportion initial value Rul is set by the worker at the time of initialization or re-initialization of the system, and is used for both Z1open and Z2open. When the answer to the query made in Step S40 is NO, it is not necessary for the degree of measurement accuracy Ra to be increased above the impedance open-circuiting proportion initial value Rul, and, therefore, Z1open is computed according to

$$Z1open = Z1ave(1 + Rul/100)$$

(Step S42).

[0037] If the answer to the query made in Step S40 is YES, it is necessary to revise Z1open based on the degree of measurement accuracy Ra, and Z1open is computed (Step S44) according to

$$Z1open = Z1ave(1 + Ra/100).$$

[0038] Following Step S42 or S44, judgment is made as to whether Z1open is larger than an upper limit value Z1ul of the impedance at 20 KHz (Step S46). The upper limit impedance value Z1ul is the upper limit value of the impedance expected to actually occur at 20 KHz when the loudspeaker line 6 etc. are open-circuited. The upper limit value Z1ul is manually set by the worker at the time of initialization or re-initialization of the system. Alternatively, Z1ave measured by DSP 10 at the time of initialization or re-initialization of the system is multiplied by a factor greater than 1, and the resultant product is set as the upper limit value Z1ul. The reason why the judgment in Step S46 is done is that it is sometimes possible for the value of Z1open revised based on the degree of measurement accuracy Ra to be an impossible value. When the answer to the query made in Step S46 is YES, Z1open is used as Z1ul (Step S48) since it is impossible that Z1open is greater than Z1ul.

[0039] Subsequent to Step S48, or when the answer to the query made in Step S46 is NO, judgment is made as to whether the degree of measurement accuracy Ra is larger than an impedance increase proportion initial value RII (Step S50). The impedance increase proportion initial value RII is a value resulting from subtracting 1 (unity) from the reciprocal of the proportion of the reference impedance (Z1ave or Z2ave) to the impedance at which the impedance of the loudspeaker line 6 and the loudspeakers 8, when the degree of measurement accuracy Ra is highest, can be considered to have decreased. The impedance increase proportion initial value RII is expressed in percent (%). The impedance increase proportion initial value RII is set by the worker when the system is initialized or re-initialized, and is used for both of Z1 inc and Z2inc. If the answer to the query in Step 50 is NO, Z1 inc is computed (Step S52) according to

$$Z1inc = Z1ave(1 + RII/100)$$

since it is not necessary to decrease the degree of measurement accuracy Ra below RII.

[0040] If the answer to the query made in Step S50 is YES, it is necessary to revise Z1 inc according to the degree of measurement accuracy Ra, and, therefore, Z1 inc is computed (Step S54) according to

$$Z1inc = Z1ave/(1 + Ra/100).$$

[0041] Subsequent to Step S52 or S54, judgment is made as to whether Z1inc is smaller than a lower limit value Z1II of the impedance Z1 at 20 KHz (Step S56). The impedance lower limit value Z1II is the lower limit value at 20 KHz at which impedance decrease is expected to actually occur while no short-circuiting has occurred in the loudspeaker line 6 or the loudspeakers 8. The lower limit value Z1II is manually set by the worker at the time of initialization or re-initialization of the system. Alternatively, the product of 21ave measured by the DSP 10 at the time of initialization or re-initialization of the system multiplied by a factor smaller than 1 (unity) is set as the lower limit value Z1II. Step S56 is executed since Z1inc revised in Step S54 sometimes takes a value which it cannot actually take. If the answer to the query made in Step S56 is YES, Z1inc is adopted as Z1II (Step S58) since it is impossible for Z1inc to be smaller than Z1II. When the execution of Step S58 is finished or if the answer to the query made in Step S56 is NO, the processing for computing Z1open and Z2open is ended.

[0042] By the processing similar to the ones described above, Z2open and Z2inc are computed, using the impedance open-circuiting proportion initial value Rul, the impedance increase proportion initial value RII, an upper limit value Z2ul of the impedance Z2 at 40 Hz, a lower limit value Z2II of the impedance Z2 at 40 Hz, and the reference impedance Z2ave of the impedance Z2 at 40 Hz. Description of this processing is not made.

[0043] Let it be assumed, for example, that Z2ave is 1,000 Ω, Z2ul is 2,000 Ω, Z2II is 500 Ω, Z2sl is 20 Ω, Z1ave is 1,500 Ω, Z1ul is 3,000 Ω, Z1II is 750 Z2, Z1sl is 30 Ω, Isl is 5 A, Rul is 10 %, RII is 10 %, Ra is 5 %, and Vtest is 5 V. The Ra of 5 % is the highest degree of accuracy. A state in which Vrms is 5 V is maintained, with the above-assumed values maintained, since Ra<Rul, Z1open and Z2open are:

$$Z2open = 1{,}000\ \Omega \times (1 + 5/100) = 1{,}050\ \Omega$$

$$Z1open = 1{,}500\ \Omega \times (1 + 5/100) = 1{,}575\ \Omega$$

Also, since Ra>RII, Z2inc and Z1 inc are:

$$Z2inc = 1{,}000\ \Omega/(1 + 5/100) = 952\ \Omega$$

$$Z1inc = 1{,}500\ \Omega/(1 + 5/100) = 1{,}428\ \Omega$$

[0044] In this condition, if the measured impedance Z2 is 1,000 Ω and the measured impedance Z1 is 1,500 Ω, it is judged by the processing shown in FIGURE 4 that the loudspeaker line is in the proper state. Similarly, if the measured impedances Z2 and Z1 are 1,100 Ω and 1,500 Ω, respectively, it is judged by the processing shown in FIGURE 4 that open-circuiting is present. If the measured impedances Z2 and Z1 are 1,100 Ω and 1,600 Ω, respectively, it is judged by the processing shown in FIGURE 4 that open-circuiting is present. If the measured impedances Z2 and Z1 are 1,000 Ω and 1,400 Ω, respectively, it is judged by the processing shown in FIGURE 4 that increase has occurred. If the measured impedances Z2 and Z1 are 15 Ω and 10 Ω, respectively, it is judged by the processing shown in FIGURE 4 that short-circuiting has occurred.

[0045] Let it be assumed that a condition in which the audio signal contains components at the same frequencies as the test signal to some extent, in addition to the test signal, and Vrms is larger than Vtest, for example, Vrms is 10 V, continues for some time, resulting in rapid increase of Ra to, for example, 50 %, due to the processing shown in FIGURE 6. Since Ra>Rul,

$$Z2open = 1{,}000\ \Omega \times (1 + 50/100) = 1{,}500\ \Omega$$

$$Z1open = 1{,}500\ \Omega \times (1 + 50/100) = 2{,}250\ \Omega$$

Also, since Ra>RII,

$$Z2inc = 1{,}000\ \Omega/(1 + 50/100) = 667\ \Omega$$

$$Z1inc = 1{,}500\ \Omega/(1 + 50/100) = 1{,}000\ \Omega$$

[0046] In this condition, if the measured impedance Z2 is 1,100 Ω and the measured impedance Z1 is 1,600 Ω, it is judged by the processing shown in FIGURE 4 that the loudspeaker line is in the normal state. If the measured impedances Z2 and Z1 are 2,300 Ω and 1,000 Ω, respectively, it is judged by the processing shown in FIGURE 4 that open-circuiting has occurred. If the measured impedances Z2 and Z1 are 1,400 Ω and 600 Ω, respectively, it is judged by the processing shown in FIGURE 4 that current has increased. If the measured impedances Z2 and Z1 are 15 Ω and 10 Ω, respectively, it is judged by the processing shown in FIGURE 4 that short-circuiting has occurred.

[0047] Let it be assumed that a condition in which the audio signal contains, in addition to the test signal, a large amount of components at the same frequencies as the test signal, and Vrms is significantly larger than Vtest, for example, Vrms is 30 V, continues for some time, resulting in rapid increase of Ra to, for example, 300 %, due to the processing shown in FIGURE 6. Since Ra>Rul,

$$Z2open = 1{,}000\ \Omega \times (1 + 300/100) = 4{,}000\ \Omega$$

$$Z1open = 1{,}500\ \Omega \times (1 + 300/100) = 6{,}000\ \Omega$$

However, since Z2open>Z2ul and Z1open>Z1ul, Z2open and Z1open are changed to:

$$Z2open = Z2ul = 2{,}000\ \Omega$$

$$Z1open = Z1ul = 3{,}000\ \Omega$$

Also, since Ra>RII,

$$Z2inc = 1{,}000\ \Omega/(1 + 300/100) = 250\ \Omega$$

$$Z1inc = 1{,}500\ \Omega/(1 + 300/100) = 375\ \Omega$$

Since Z2inc<Z2II and Z1inc<Z1II, Z2inc ad Z1 inc are changed to:

$$Z2inc = Z2II = 500\ \Omega$$

$$Z1inc = Z1II = 750\ \Omega$$

[0048] In this condition, if the measured impedance Z2 is 1,000 Ω and the measured impedance Z1 is 1,600 Ω, it is judged by the processing shown in FIGURE 4 that the loudspeaker line is normal. If the measured impedances Z2 and Z1 are 2,500 Ω and 2,800 Ω, respectively, it is judged by the processing shown in FIGURE 4 that open-circuiting has occurred. If the measured impedances Z2 and Z1 are 400 Ω and 1,000 Ω, respectively, it is judged by the processing shown in FIGURE 4 that current has increased. If the measured impedances Z2 and Z1 are 15 Ω and 10 Ω, respectively, it is judged by the processing shown in FIGURE 4 that short-circuiting has occurred.

[0049] Even if the state in which Vrms is 30 V returns to the state in which Vrms is 10 V, for example, Ra does not change to 50 %, but only decreases slightly, due to the processing of Step S34 in FIGURE 6. Accordingly, Z2open slightly decreases from 4,000 Ω. Z1open slightly decreases from 6,000 Ω, Z2inc slightly increases from 500 Ω, and Z1 inc slightly increases from 750 Ω. With this arrangement, if, for example, the loudspeakers 8 generate heat due to a large value of Vrms, and it takes a long time for the temperature of the loudspeakers 8 to return to the temperature before they began to generate heat, erroneous judgment can be avoided since it takes a long time for Z1open, Z2open, Z1 inc and Z2inc to return to their values before the heat generation occurred.

[0050] In this examination system, the reference impedances Z1 ave and Z2ave at 20 KHz and 40 Hz of the loudspeaker line 6 and the loudspeakers 8 are measured prior to the application of the audio signal, and judgment is made as to whether the reference impedance Z1 ave is between predetermined allowable aging upper and lower limit values Z1UL and Z1LL for 20 KHz, or whether the reference impedance Z2ave is between predetermined allowable aging upper and lower limit values Z2UL and Z2LL for 40 Hz. Specifically, as the public address system is operated for a long time, the impedance of the loudspeakers 8 changes due to aging, and the reference impedances Z1 ave and Z2ave also change as the impedance of the loudspeakers 8 changes. Judgment is made as to whether the reference impedance Z1 ave is within an allowable range defined by the allowable upper limit Z1 UL and the allowable lower limit Z1LL, which are the limits for 20 KHz indicating the necessity for replacement of the loudspeakers, or whether the reference impedance Z2ave is within an allowable range defined by the allowable upper limit Z2UL and the allowable lower limit Z2LL, which are the limits for 40 Hz indicating the necessity for replacement of the loudspeakers. If the reference impedance Z1ave is outside the allowable range defined by the allowable upper limit Z1 UL and the allowable lower limit Z1 LL, or if the reference impedance Z2ave is outside the allowable range defined by the allowable upper limit Z2UL and the allowable lower limit Z2LL, an indication to recommend the replacement of loudspeakers is displayed on the notification device 28. Such judgment is made at a time when the public address system is not in use. For example, if the public address system is installed in a store, the judgment is made everyday at a given time within a time period after the store is closed and before the store is opened.

[0051] As shown in FIGURE 9, whether the time for examination comes or not is judged (Step S60). If the answer to the query made in Step S60 is NO, the processing is ended. If the answer is YES, the DSP 10 provides the test signal (Step S62). Then, the reference impedances Z1 ave and Z2ave are measured in the manner described with reference to FIGURE 2 (Step S64). Judgment is made as to whether Z1 ave is within the above-described allowable range defined by Z1UL and Z1LL and, at the same time, whether Z2ave is within the above-described allowable range defined by Z2UL and Z2LL (Step S66). If the answer to the query made in Step S66 is NO, an error notification is displayed on the notification device 28 (Step S68) to recommend replacement of a loudspeaker. If the answer is YES, the measured Z1 ave and Z2ave are stored (Step S70). The execution of the processing of Step S70 renews Z1 ave and Z2ave for use in computing Z1open, Z2open, Z1 inc and Z2inc in the processing shown in FIGURE 8 in later stages. This prevents erroneous judgment which would be caused by influence given by changes in impedance caused by aging.

[0052] According to the described embodiment, cross-spectrum analysis is used to determine the impedances Z1, Z2, Z1ave and Z2ave, but the impedances may be determined by using a band-pass filter having a narrow band capable of deriving the test signal to derive current and voltage of the test signal, and determine the impedances from the derived current and voltage, for example. Also, according to the described embodiment, the test signal used has frequencies of 40 Hz and 20 KHz, but a test signal at either one of 40 Hz and 20 KHz, for example, may be used instead. Further, according to the described embodiment, the digital test signal from the DSP 10 is digital-to-analog converted and the resultant analog test signal is applied to the combiner 13. Instead, an analog test signal source is additionally used and a test signal from this analog test signal source may be applied to the combiner 13. In such case, the analog test signal is analog-to-digital converted and the resultant digital signal is applied to the DSP 10. According to the described embodiment, open-circuiting and decrease in impedance of the loudspeaker line and loudspeakers are determined, but only one of them may be determined, instead.

Claims

1. A public address system comprising:

    a signal source (2) of an audio signal;
    an amplifier (4) for amplifying said audio signal;
    a loudspeaker line (6) through which an output signal of said amplifier is transmitted;
    a plurality of loudspeakers (8) connected in parallel with each other to said loudspeaker line; and
    a loudspeaker line examination system, said loudspeaker line examination system being for examining said loudspeaker line (6) and comprising:

        a signal source (10) of a test signal containing a frequency near a lowest frequency of a human audio frequency band and/or a frequency near a highest frequency of the human audio frequency band;
        a combiner (13) for combining said test signal with said audio signal and applying a resultant signal to said amplifier;
        impedance determining means (10, 14, 16) for deriving a component of said test signal contained in an output signal of said amplifier and determining, from the derived test signal component, an impedance viewed from the output of said amplifier toward said loudspeakers;
        judging means for comparing the determined impedance with a predetermined upper limit threshold value for use in detecting open-circuiting of said loudspeaker line (6) and loudspeakers (8), and a predetermined lower limit threshold value for use in detecting decrease in impedance of said loudspeaker line (6) and loudspeakers (8), to judge whether one of open-circuiting and decrease in impedance of said loudspeaker line and loudspeakers has occurred; and
        threshold value revising means for changing one of said upper limit and lower limit threshold values in a direction to decrease an accuracy of judgment of said judging means if a proportion of said resultant signal to said test signal is larger than a predetermined value and said resultant signal is increasing.

2. The public address system according to Claim 1, wherein said threshold value revising means, when a state of said resultant signal changes from a state in which said resultant signal increases to a state in which said resultant signal decreases, increases said accuracy of judgment decreased when said resultant signal is increasing, a rate of change in a direction to decrease said accuracy of judgment being larger, a rate of change in a direction to increase said accuracy of judgment being smaller.

3. The public address system according to Claim 1, wherein:

said impedance determining means determines said impedance in a time period during which said signal source of audio signal is not operating; and
said public address system further comprises:

threshold value setting means for setting said upper limit and/or lower limit threshold values based on the determined impedance; and
second judging means for judging whether said determined impedance is within a predetermined allowable range.

4. The public address system according to Claim 1, wherein said impedance determining means comprises:

current detecting means for detecting current flowing through said loudspeaker line;
voltage detecting means for detecting a voltage applied to said loudspeaker line;
frequency component detecting means for detecting a frequency component of said test signal contained in the current as detected by said current detecting means and in the voltage as detected by said voltage detecting means; and
computing means for computing said impedance from the test signal frequency components in said detected current and voltage.

Patentansprüche

1. Öffentliches Adresssystem, umfassend:

eine Signalquelle (2) eines Audiosignals;
ein Verstärker (4) zur Verstärkung des Audiosignals;
eine Lautsprecherleitung (6), durch die ein Ausgangssignal des Verstärkers übermittelt wird;
mehrere Lautsprecher (8), die parallel zueinander mit der Lautsprecherleitung verbunden sind; und
ein Lautsprecherleitungsprüfsystem, das der Prüfung der Lautsprecherleitung (6) dient und umfasst:

eine Signalquelle (10) eines Prüfsignals, welches eine Frequenz nahe an einer niedrigsten Frequenz eines menschlichen Audiofrequenzbandes und/oder eine Frequenz nahe an einer höchsten Frequenz des menschlichen Audiofrequenzbandes enthält;
ein Kombinator (13) zur Kombination des Testsignals mit dem Audiosignal und Übertragung eines daraus entstehenden Signals an den Verstärker;
eine Impedanz-Bestimmungseinrichtung (10, 14, 16) zum Ableiten einer Komponente des in einem Ausgangssignal des Verstärkers enthaltenen Prüfsignals und Bestimmung, aus der abgeleiteten Prüfsignalkomponente, einer Impedanz, betrachtet vom Ausgang des Verstärkers in Richtung des Lautsprechers;
eine Beurteilungseinrichtung zum Vergleichen der ermittelten Impedanz mit einem vorbestimmten oberen Schwellenwert zur Verwendung bei der Erkennung von Unterbrechungen der Lautsprecherleitung (6) und der Lautsprecher (8) und einem vorbestimmten unteren Schwellenwert zur Verwendung bei der Erkennung von Impedanzabnahmen genannter Lautsprecherleitung (6) und Lautsprecher (8), um zu beurteilen, ob eine Unterbrechung und eine Abnahme der Impedanz der Lautsprecherleitung und der Lautsprecher eingetreten ist; und
eine Schwellenwertänderungseinrichtung zur Änderung eines der oberen und unteren Schwellenwerte in eine Richtung zur Verringerung der Beurteilungsgenauigkeit der Beurteilung, falls ein Verhältnis des resultierenden Signals zum Prüfsignal größer als ein vorgegebener Wert ist und das resultierende Signal zunimmt.

2. Öffentliches Adresssystem nach Anspruch 1, bei welchem die Schwellenwertänderungseinrichtung, sobald der Zustand des resultierenden Signals von einem Zustand, in welchem das resultierende Signal zunimmt, in einen Zustand wechselt, in welchem das resultierende Signal abnimmt, die Beurteilungsgenauigkeit erhöht, welche abnimmt, wenn das resultierende Signal ansteigt, wobei eine Änderungsrate in einer Richtung zur Verringerung der Beurteilungsgenauigkeit größer und eine Änderungsrate in einer Richtung zur Erhöhung der Beurteilungsgenauigkeit geringer ist.

3. Öffentliches Adresssystem nach Anspruch 1, worin:

die Impedanz-Bestimmungseinrichtung die Impedanz in einem Zeitraum bestimmt, in welchem die Signalquelle des Audiosignals nicht in Betrieb ist; und
öffentliches Adresssystem ferner umfasst:

eine Schwellenwert-Einstelleinrichtung für das Einstellen der oberen und/oder unteren Schwellenwerte auf Grundlage der ermittelten Impedanz; sowie
eine zweite Beurteilungseinrichtung zum Beurteilen, ob die ermittelte Impedanz innerhalb eines vorgegebenen zulässigen Bereichs liegt.

4. Öffentliches Adresssystem nach Anspruch 1, worin die Impedanz-Bestimmungseinrichtung umfasst:

eine Stromfeststellungseinrichtung zum Feststellen von durch die Lautsprecherleitung fließendem Strom;
eine Spannungsfeststellungseinrichtung zum Feststellen einer an der Lautsprecherleitung anliegenden Spannung;
eine Frequenzkomponenten-Feststellungseinrichtung für das Feststellen einer Frequenzkomponente des im Strom enthaltenen Prüfsignals, wie es von der Stromfeststellungseinrichtung festgestellt wird, und des in der Spannung enthaltenen Prüfsignals, wie es von der Spannungsfeststellungseinrichtung festgestellt wird; sowie
eine Berechnungseinrichtung zur Berechnung der Impedanz aus den Prüfsignal-Frequenzkomponenten im/in dem/der festgestellten Strom und Spannung.

Revendications

1. Système de diffusion publique comprenant :

une source de signal (2) d'un signal audio ;
un amplificateur (4) afin d'amplifier ledit signal audio ;
une ligne de haut-parleur (6) à travers laquelle est transmis un signal de sortie dudit amplificateur ;
une pluralité de haut-parleurs (8) connectés les uns aux autres en parallèle à ladite ligne de haut-parleur ; et
un système d'inspection de lignes de haut-parleurs, ledit système d'inspection étant destiné à l'inspection de ladite ligne de haut-parleur (6) et comprenant :

une source de signal (10) d'un signal d'essai contenant une fréquence proche de la plus basse fréquence d'une bande de fréquence audio humaine et/ou une fréquence proche de la fréquence la plus élevée de la bande de fréquence audio humaine ;
un combineur (13) permettant la combinaison dudit signal d'essai avec ledit signal audio et l'application d'un signal résultant audit amplificateur ;
un moyen de détermination d'impédance (10, 14, 16) permettant la dérivation d'une composante dudit signal d'essai contenu dans un signal de sortie dudit amplificateur et la détermination, à partir de la composante de signal d'essai dérivée, d'une impédance vue depuis la sortie dudit amplificateur vers lesdits haut-parleurs ;
un moyen d'évaluation permettant la comparaison de l'impédance déterminée à une valeur de seuil limite supérieure prédéterminée à utiliser pour la détection d'une ouverture de circuit de ladite ligne de haut-parleur (6) et des haut-parleurs (8), et une valeur seuil limite prédéterminée à utiliser pour la détection d'une diminution d'impédance de ladite ligne de haut-parleur (6) et des haut-parleurs (8), pour évaluer si l'un des ouvertures de circuit et une diminution d'impédance de ladite ligne de haut-parleur et des haut-parleurs est survenu ; et
un moyen de révision de valeur seuil permettant la modification de l'une desdites valeurs seuil limite supérieure et limite inférieure dans une direction afin de diminuer une précision d'évaluation dudit moyen d'évaluation si une proportion dudit signal résultant audit signal d'essai est supérieure à une valeur prédéterminée et audit signal résultant augmente.

2. Système de diffusion publique selon la revendication 1, dans lequel ledit moyen de révision de valeur seuil, lorsqu'un état dudit signal résultant passe d'un état dans lequel ledit signal résultant augmente à un état dans lequel ledit signal résultant diminue, augmente ladite précision d'évaluation diminuée lorsque ledit signal résultant augmente, une taux de variation dans une direction pour diminuer ladite précision d'évaluation qui est plus grande, un taux variation dans une direction pour augmenter ladite précision d'évaluation qui est plus petite.

3. Système de diffusion publique selon la revendication 1, dans lequel :

ledit moyen de détermination d'impédance détermine ladite impédance dans une période de temps pendant laquelle ladite source de signal de signal audio ne fonctionne pas ; et
ledit système de diffusion publique comprend en outre :

un moyen d'établissement de valeur seuil permettant l'établissement desdites valeurs seuil de limite supérieure et/ou inférieure en fonction de l'impédance déterminée ; et
un second moyen d'évaluation permettant l'évaluation du fait que l'impédance déterminée est dans une plage autorisée prédéterminée.

4. Système de diffusion publique selon la revendication 1, dans lequel ledit moyen de détermination d'impédance comprend :

un moyen de détection de courant permettant la détection du courant circulant dans ladite ligne de haut-parleur ;
un moyen de détection de tension permettant la détection d'une tension appliquée à ladite ligne de haut-parleur ;
un moyen de détection de composante de fréquence permettant la détection d'une composante de fréquence dudit signal d'essai contenu dans le courant tel que détecté par ledit moyen de détection de courant et dans la tension telle que détectée par ledit moyen de détection de tension ; et
un moyen de calcul permettant le calcul de ladite impédance à partir des composantes de fréquence du signal d'essai dans lesdits courant et tension détectés.

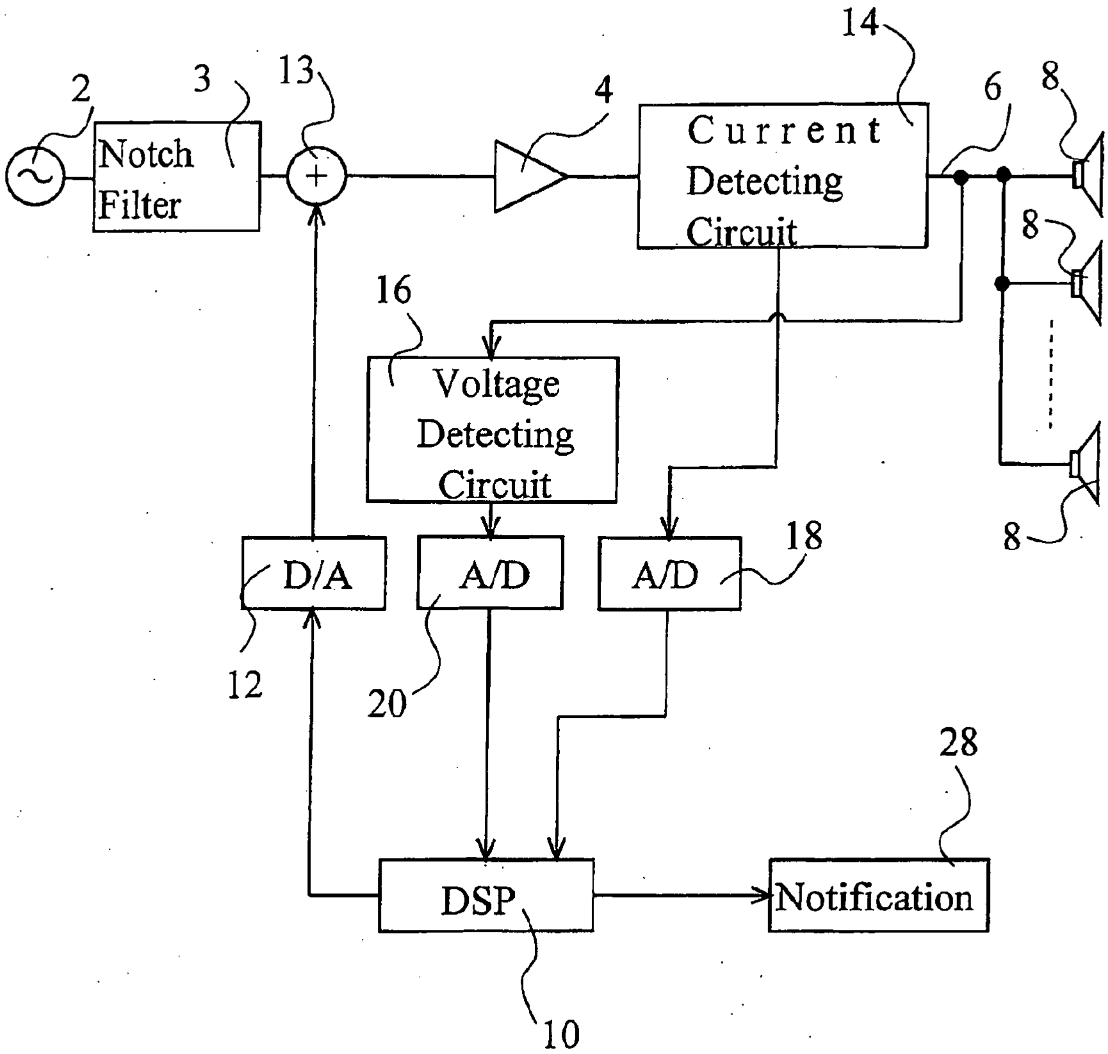
2
3
Notch Filter
13
+
4
14
Current Detecting Circuit
6
8
8
8
16
Voltage Detecting Circuit
D/A
A/D
A/D
18
12
20
28
DSP
Notification
10

Fig.1

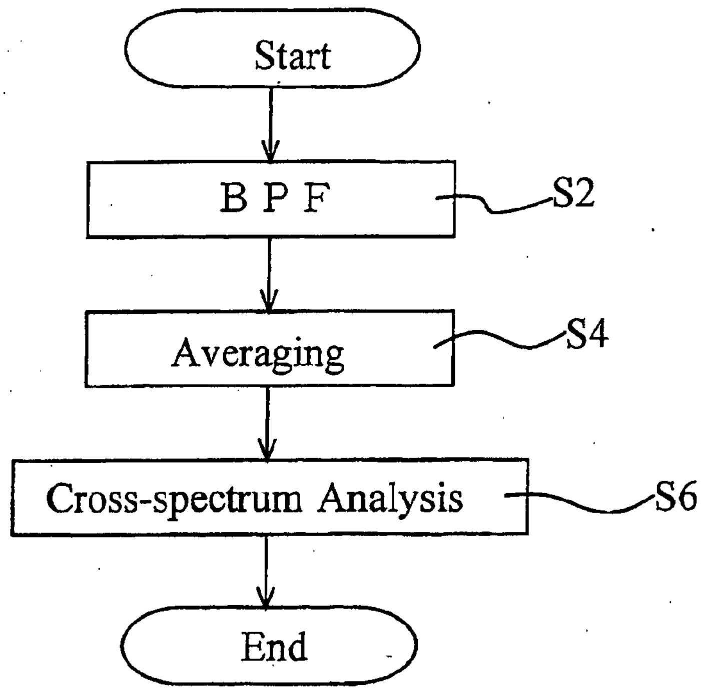
Start
B P F
S2
Averaging
S4
Cross-spectrum Analysis
S6
End

Fig.2

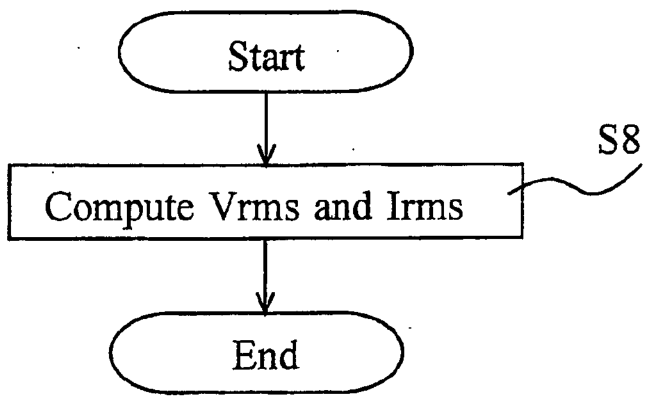
Start
S8
Compute Vrms and Irms
End

Fig.3

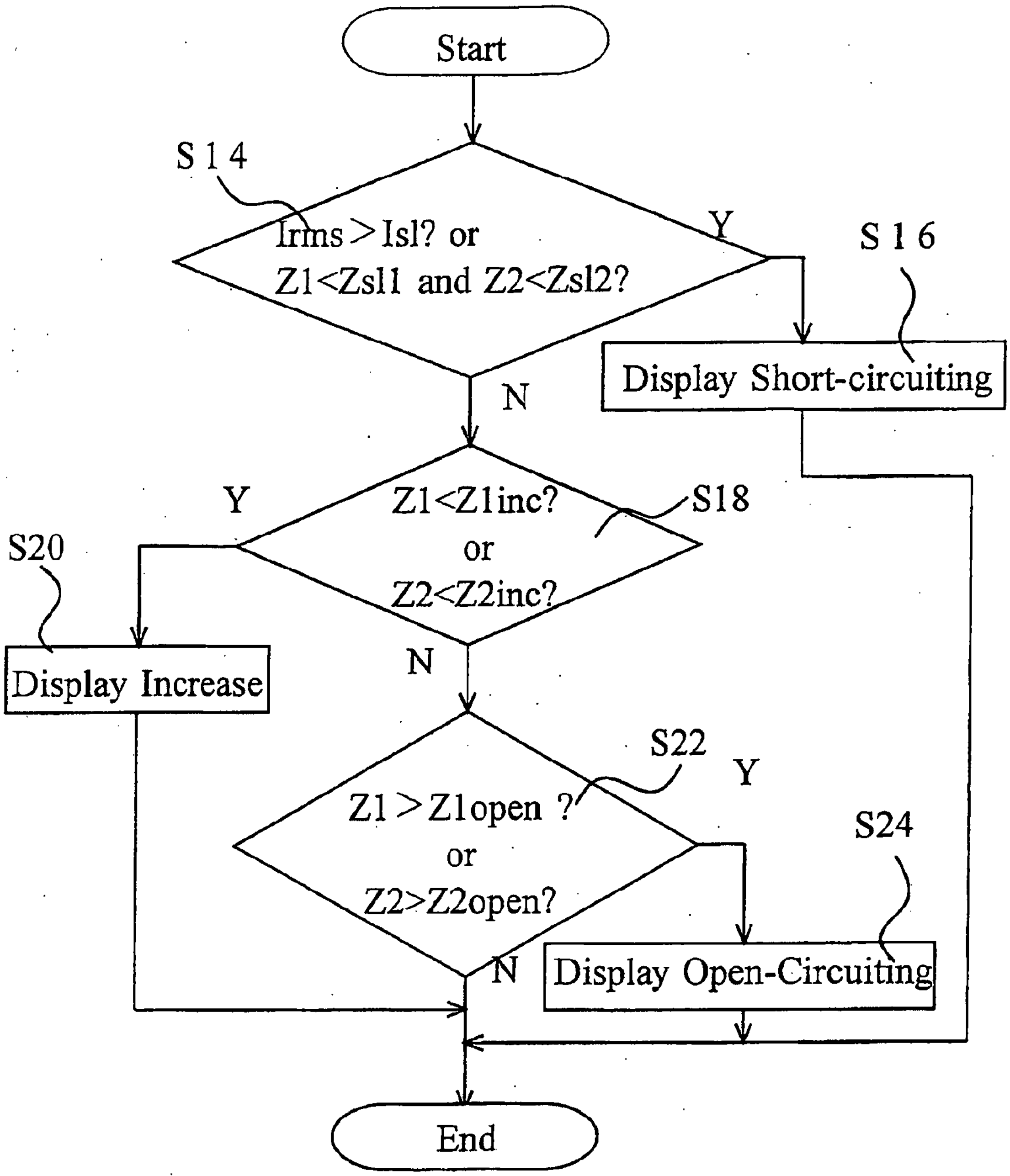
Start
S14
Irms > Isl? or
Z1<Zsl1 and Z2<Zsl2?
Y
S16
Display Short-circuiting
N
Y
Z1<Z1inc?
or
Z2<Z2inc?
S18
S20
Display Increase
N
S22
Y
Z1 > Z1open ?
or
Z2>Z2open?
S24
N
Display Open-Circuiting
End

Fig.4

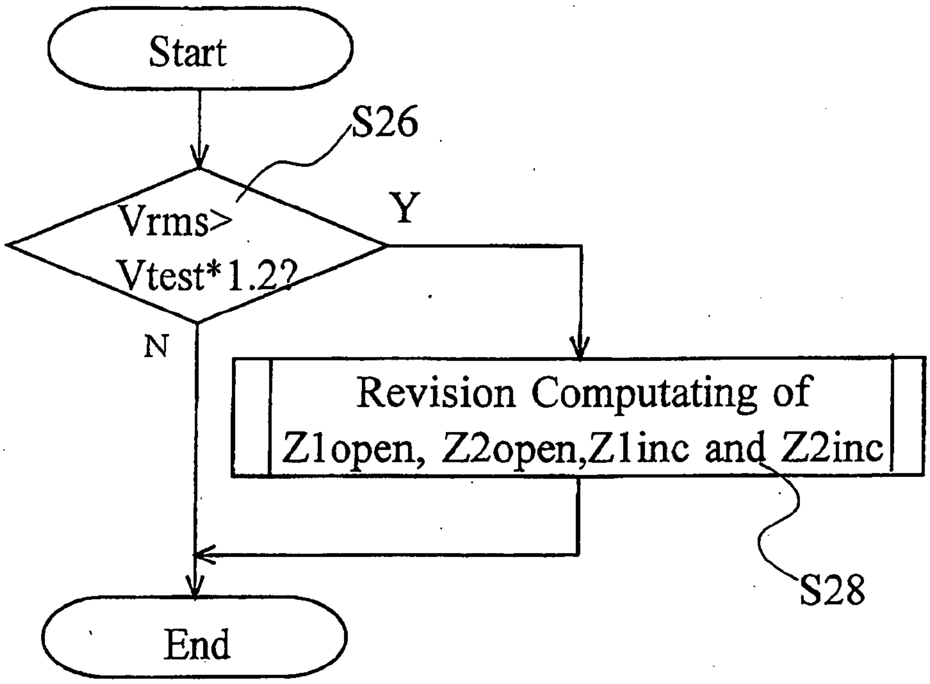
Start
S26
Vrms>
Vtest*1.2?
Y
N
Revision Computating of
Z1open, Z2open,Z1inc and Z2inc
S28
End

Fig.5

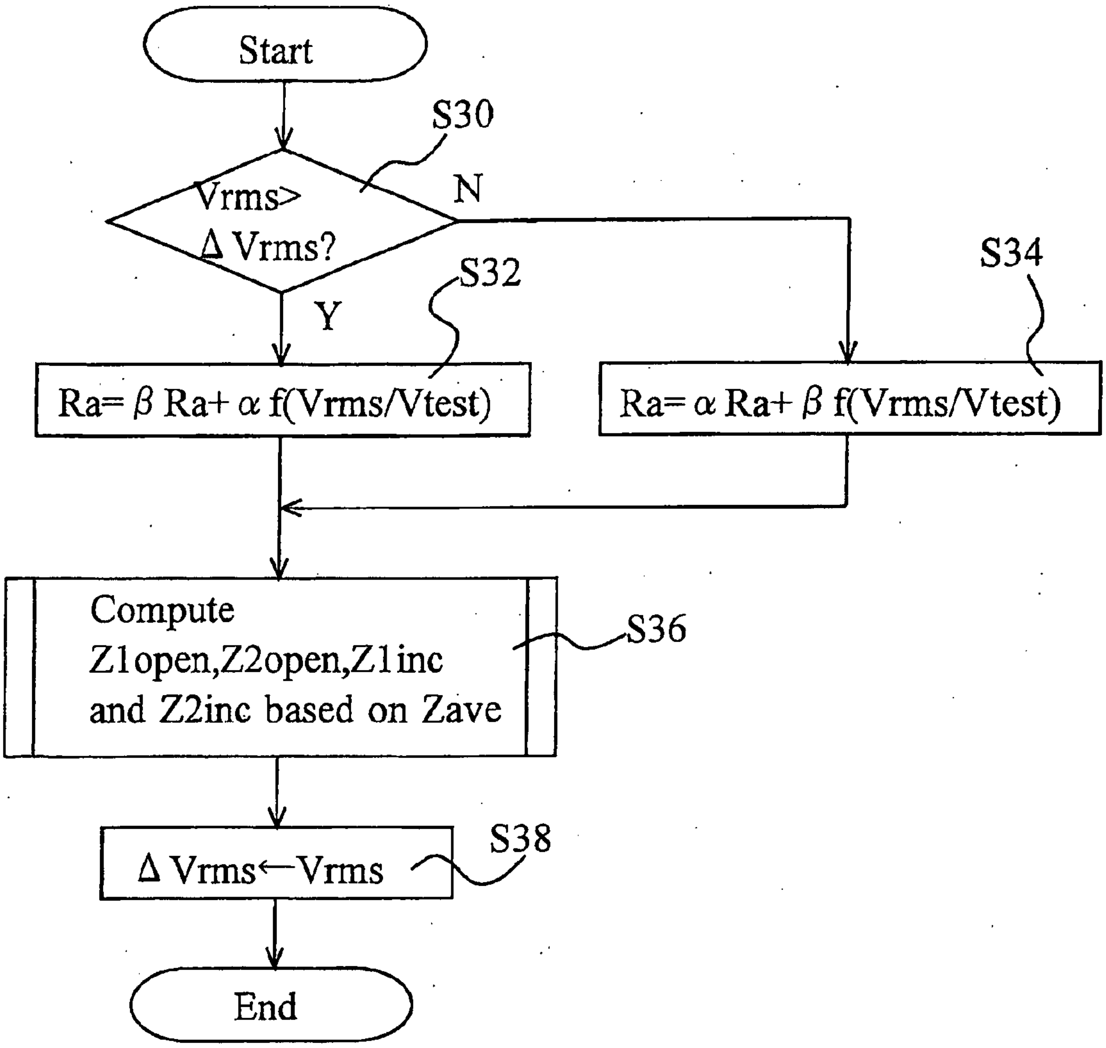
Start
S30
Vrms>
Δ Vrms?
N
Y
S32
S34
Ra= β Ra+ α f(Vrms/Vtest)
Ra= α Ra+ β f(Vrms/Vtest)
Compute
Z1open,Z2open,Z1inc
and Z2inc based on Zave
S36
Δ Vrms←Vrms
S38
End

Fig.6

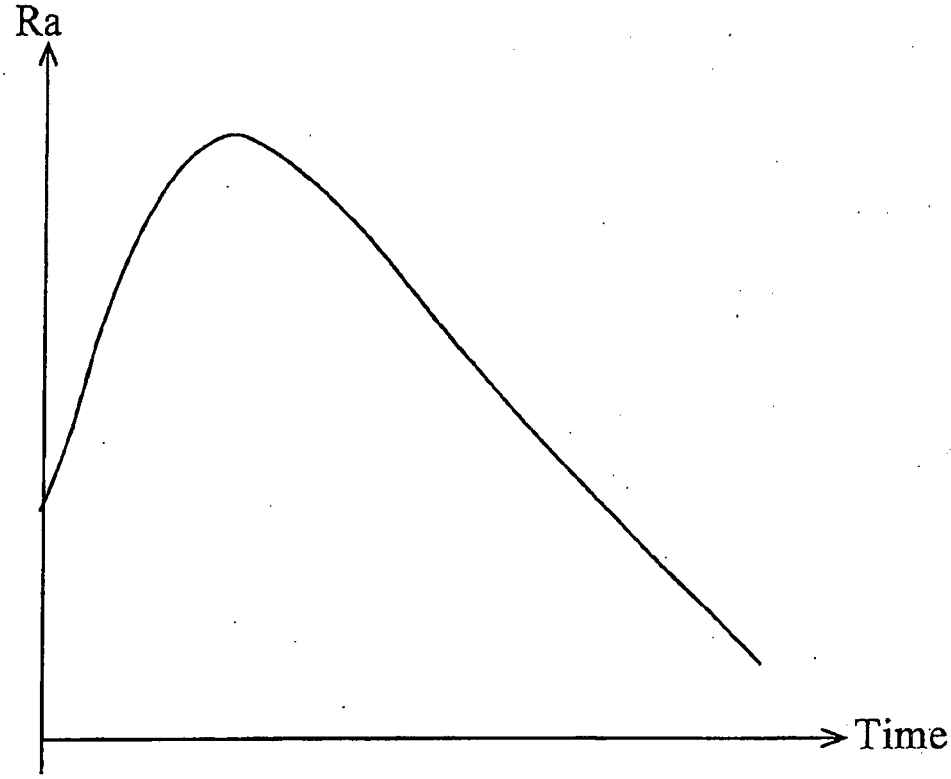

Fig.7

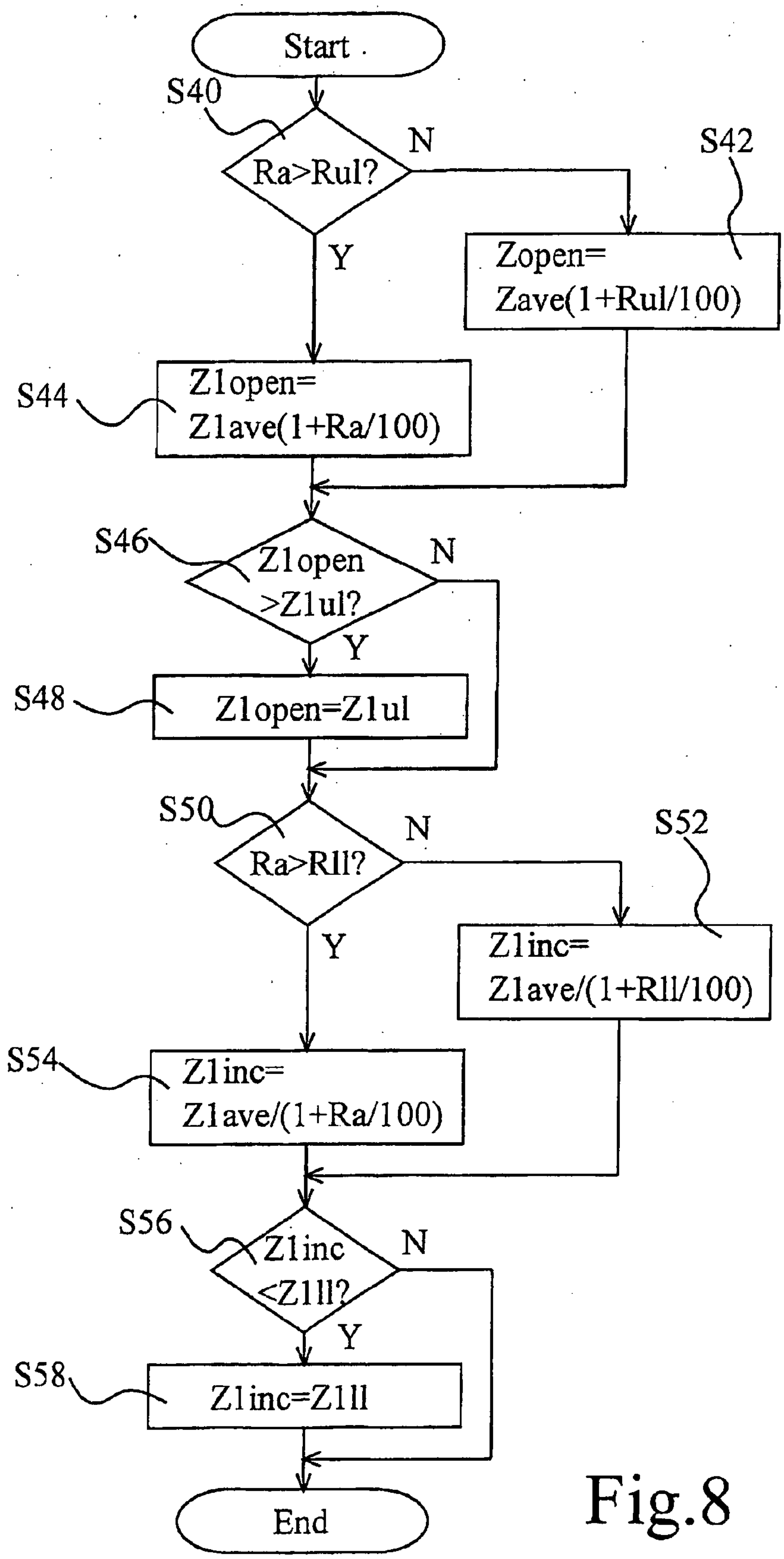
Start
S40
Ra>Rul?
N
Y
S42
Zopen=
Zave(1+Rul/100)
S44
Z1open=
Z1ave(1+Ra/100)
S46
Z1open
>Z1ul?
N
Y
S48
Z1open=Z1ul
S50
Ra>Rll?
N
Y
S52
Z1inc=
Z1ave/(1+Rll/100)
S54
Z1inc=
Z1ave/(1+Ra/100)
S56
Z1inc
<Z1ll?
N
Y
S58
Z1inc=Z1ll
End

Fig.8

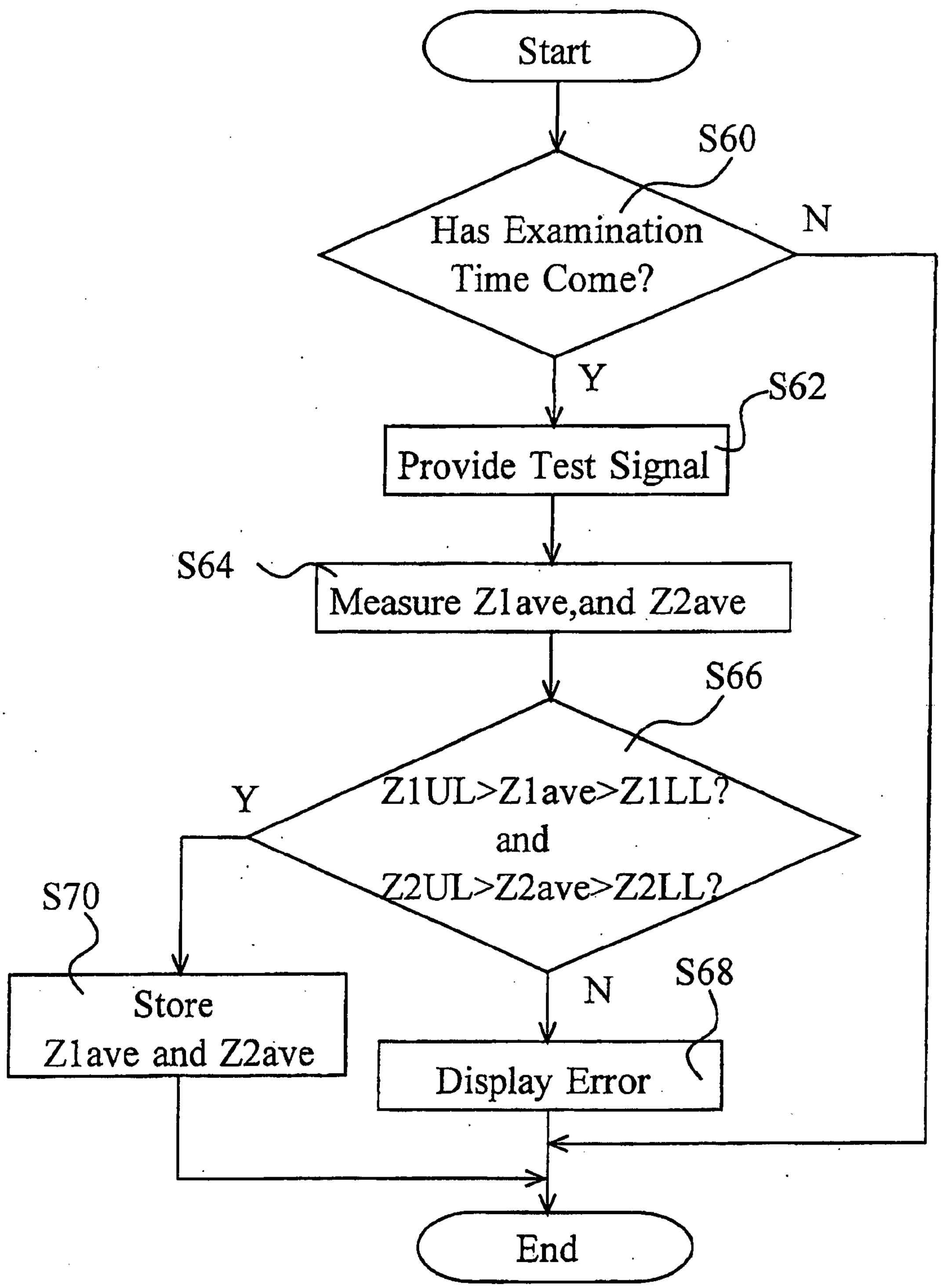
Start
S60
Has Examination
Time Come?
N
Y
S62
Provide Test Signal
S64
Measure Z1ave,and Z2ave
S66
Y
Z1UL>Z1ave>Z1LL?
and
Z2UL>Z2ave>Z2LL?
S70
Store
Z1ave and Z2ave
N
S68
Display Error
End

Fig.9

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2007037024 A **[0003]**