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

(11) **EP 3 936 409 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
12.01.2022 Bulletin 2022/02

(21) Application number: **19917671.0**

(22) Date of filing: **26.11.2019**

(51) Int Cl.:
B61L 3/12 *(2006.01)* ***B61L 23/14*** *(2006.01)*
H04B 17/19 *(2015.01)* ***B60L 3/00*** *(2019.01)*

(86) International application number:
PCT/JP2019/046135

(87) International publication number:
WO 2020/179151 (10.09.2020 Gazette 2020/37)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **04.03.2019 JP 2019038592**

(71) Applicant: **Hitachi, Ltd.**
Tokyo 100-8280 (JP)

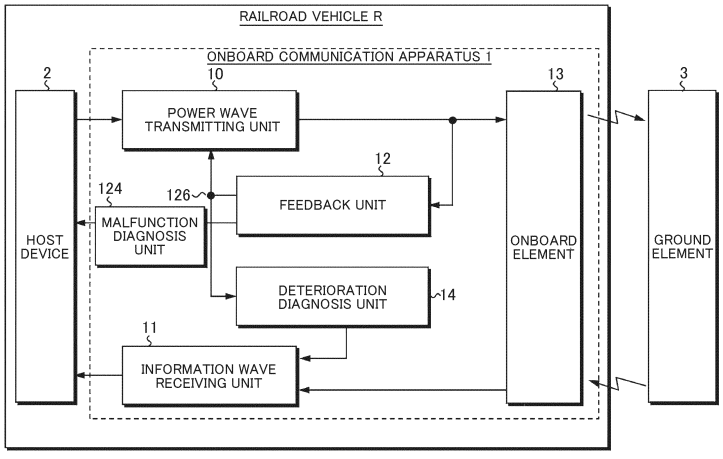
(72) Inventors:
- **SATO, Shinnosuke**
  Tokyo 100-8280 (JP)
- **HASEGAWA, Osamu**
  Tokyo 100-8280 (JP)

(74) Representative: **Mewburn Ellis LLP**
Aurora Building
Counterslip
Bristol BS1 6BX (GB)

(54) ONBOARD COMMUNICATION APPARATUS AND RAILROAD VEHICLE

(57) The present invention provides a technique for detecting a sign of a malfunction in an onboard communication apparatus. Accordingly, one representative onboard communication apparatus according to the present invention is an onboard communication apparatus which is installed in a vehicle and which transmits power waves to, and receives information waves from, a ground element installed along a railroad track, the apparatus comprising: a power wave transmitting unit that generates power waves; an onboard element that transmits the power waves generated by the power wave transmitting unit to the ground element and receives information waves transmitted by the ground element; a feedback unit that detects output of the power waves and stabilizes the output to a prescribed output; and a deterioration diagnosis unit that outputs, as information indicating a sign of a malfunction ("deterioration information" hereinafter), information based on a feedback command value of the feedback unit.

FIG.1



EP 3 936 409 A1

Description

Technical Field

[0001] The present invention relates to an onboard communication apparatus and a railroad vehicle.

Background Art

[0002] An onboard element of an onboard communication apparatus installed in a vehicle performs transmission and reception of information waves to and from a ground element of a ground communication apparatus installed on the road. Data such as a speed limit and position information of the vehicle obtained from the ground element is used for control on the operation of the vehicle, etc.

[0003] The ground communication apparatus includes a powered ground communication apparatus supplied with power from the ground, and a non-powered ground communication apparatus which is powered and started by power waves transmitted from the onboard communication apparatus. Both ground communication apparatuses perform transmission and reception of information waves at frequencies different from the power waves.

[0004] Here, in order to start up the non-powered ground communication apparatus and communicate reliably, there is a need to transmit stable power from the onboard element to the ground element. However, in the case where an unexpected malfunction occurs in the apparatus, the power waves transmitted from the onboard element may fall outside a specified range. Therefore, the apparatus may be provided with a function of monitoring that the power waves of the onboard element are within the specified range.

[0005] There have been described in Patent Literature 1, for example that "there is provided a power wave transmission level monitor unit which monitors a power wave level transmitted to an onboard element, and feedback control is performed which adjusts a power wave transmission set value according to the power wave level acquired by this monitor unit, and that "it is judged whether or not the output value of a power wave monitor is out of a specified range".

Citation List

Patent Literature

[0006] PTL 1: Japanese Patent Application Laid-Open No. 2017-195486

Summary of Invention

Technical Problem

[0007] In Patent Literature 1, a malfunction is detected when the power wave level falls outside the specified range.

[0008] However, in Patent Literature 1, since the power wave level is fed back to adjust the output level of the power waves, the power wave level is kept within the specified range. Therefore, the power wave level will be out of the specified range only when a malfunction that cannot be covered by the feedback control occurs. Thus, when an abnormality is detected at the power wave level, the apparatus in which malfunction has occurred must be replaced, which may cause a problem in operation.

[0009] Therefore, the present invention provides a technique for detecting a sign of a malfunction of an onboard communication apparatus.

Solution to Problem

[0010] One of typical onboard communication apparatuses of the present invention is an onboard communication apparatus which transmits power waves to and receives information waves from a ground element installed on a railroad track. The onboard communication apparatus includes a power wave transmitting unit which generates power waves, an onboard element which transmits the power waves generated by the power wave transmitting unit to the ground element and receives information waves transmitted by the ground element, a feedback unit which detects output of the power waves and stabilizes the output to a prescribed output, and a deterioration diagnosis unit which outputs information based on a feedback command value of the feedback unit as information indicating a sign of a malfunction (hereinafter "deterioration information").

Advantageous Effects of Invention

[0011] According to the present invention, it is possible to detect a sign of a malfunction of the onboard communication apparatus.

[0012] Problems, configurations, and effects other than those described above will be clarified by the description of the following embodiments.

Brief Description of Drawings

[0013]

Fig. 1 is a block diagram showing an onboard communication apparatus according to a first embodiment.

Fig. 2 is a block diagram showing a detailed configuration of each part of the onboard communication apparatus.

Fig. 3 is an explanatory diagram for comparing and explaining a secular change in a power wave level and a secular change in a feedback command value.

Fig. 4 is a block diagram showing an onboard communication apparatus according to a second embodiment.

Fig. 5 is a block diagram showing an onboard communication apparatus according to a third embodiment.

Fig. 6 is a flowchart illustrating a start-up sequence of an onboard communication apparatus according to a fourth embodiment.

Fig. 7 is a block diagram showing an onboard communication apparatus according to a fifth embodiment.

Description of Embodiments

[0014] Hereinafter, as embodiments of the present invention, detailed description thereof will be made with reference to the drawings.

<First embodiment>

[0015] Fig. 1 is a block diagram showing an onboard communication apparatus installed in a railroad vehicle R.

[0016] The railroad vehicle R includes an onboard communication apparatus 1 and a host device 2.

[0017] The onboard communication apparatus 1 includes a power wave transmitting unit 10, an information wave receiving unit 11, a feedback unit 12, an onboard element 13, a deterioration diagnosis unit 14, and a malfunction diagnosis unit 124.

[0018] The power wave transmitting unit 10 generates power waves in accordance with a power wave transmission command of the host device 2. The generated power waves are sent to a ground element 3 of a ground communication apparatus via the onboard element 13. At this time, the feedback unit 12 monitors an output level of the power wave transmitting unit 10 and performs feedback control to suppress the gain of the power waves when the output level is higher than a target value, and increase the gain of the power waves when the output level is lower than the target value.

[0019] When the output level of the power waves is out of a specified range despite the control of the feedback unit 12, the malfunction diagnosis unit 124 judges that the power wave transmitting unit 10 or the onboard element 13 which is the load has malfunctioned, and transmits a signal notifying the host device 2 of its malfunction.

[0020] The information wave receiving unit 11 receives information waves transmitted by the ground element 3 of the ground communication apparatus by the onboard element 13. The information wave receiving unit 11 demodulates the information waves and transfers it to the host device 2 as an information wave telegram.

[0021] The deterioration diagnosis unit 14 acquires a command value (hereinafter referred to as a "feedback command value 126") such as a gain command of the power waves output by the feedback unit 12. The deterioration diagnosis unit 14 transfers to the information wave receiving unit 11 as deterioration information (information indicating a sign of a malfunction) of a power wave transmission system, the feedback command value 126 itself, or feedback information calculated from the feedback command value 126, information as to whether or not the feedback command value 126 exceeds a deterioration judgement threshold, deterioration diagnosis information estimated from a change with time of the feedback command value 126, or the like.

[0022] The information wave receiving unit 11 attaches an "identifier such as a flag indicating deterioration information" to the deterioration information received from the deterioration diagnosis unit 14 and transmits it to the host device 2 by using the same transmission path as the information wave telegram of the information waves received from the onboard element 13.

[0023] Fig. 2 is a block diagram showing a detailed configuration of each part of the onboard communication apparatus.

[0024] The power wave transmitting unit 10 is configured of a power wave control part 101 which controls the frequency setting of the power waves and output ON/OFF according to the power wave transmission command of the host device 2, a DDS 102 (Direct Digital Synthesizer) which generates a sine wave signal which becomes the source of the power waves under the control of the power wave control part 101, a preamplifier 103 which amplifies the sine wave signal of the DDS 102, a variable attenuator 104 which attenuates the output of the preamplifier 103 to perform level adjustment according to the feedback command value 126, a main amplifier 105 which power-amplifies the power waves whose level is adjusted by the variable attenuator 104, and a low-pass filter 106 which removes distortion of the output waveform of the main amplifier.

[0025] The information wave receiving unit 11 is configured of a bandpass filter 114 which removes unnecessary frequencies of the information waves received from the onboard element 13, a preamplifier 113 which amplifies the output of the bandpass filter 114, an A/D converter 112 which converts the output of the preamplifier 113 into a digital signal, and an information wave control part 111 which decodes the converted digital signal and transmits it to the host device 2 as an information wave telegram.

[0026] Further, transformers 15 for insulation and balance-unbalance conversion are provided between the power wave transmitting unit 10 and the onboard element 13 and between the information wave receiving unit 11 and the onboard element 13, respectively.

[0027] The feedback unit 12 is configured of a power wave monitor 123 which measures an output current of the power wave transmitting unit 10 and outputs a power wave monitor signal corresponding to the power wave level, an A/D converter 112 which converts the output of the power wave monitor 123 into a digital signal, a level control part 121 which outputs a feedback command value 126 for increasing an attenuation amount of the variable attenuator 104 when the digitally-converted power wave monitor signal is higher than a target value and

decreasing the attenuation amount when the power wave monitor signal is lower than the target value, and a D/A converter 125 which converts the feedback command value 126 into an analog signal.

[0028] Further, when the digitally-converted power wave monitor signal exceeds the specified range, the malfunction diagnosis unit 124 judges that malfunction has occurred in the power wave transmitting unit 10, and transmits a signal to notify the detection of the malfunction to the host device 2.

[0029] On the other hand, the deterioration diagnosis unit 14 acquires the same signal as the feedback command value 126 which controls the variable attenuator 104 from the level control part 121. The deterioration diagnosis unit 14 attaches an identifier indicating that effect to the deterioration information based on the feedback command value 126 and outputs the deterioration information to the information wave control part 111.

[0030] The information wave control part 111 preferentially transmits the information wave telegram of the information waves received from the onboard element 13 to the host device 2, and transmits the deterioration information received from the deterioration diagnosis unit 14 to the host device 2 when the information waves are not received from the onboard element 13.

[0031] The host device 2 can grasp a deterioration state of the power wave transmission system of the onboard communication apparatus 1, based on the deterioration information received via the information wave control part 111.

[0032] Here, description will be made as to the difference in operation between the deterioration diagnosis unit 14 and the malfunction diagnosis unit 124.

[0033] Fig 3 is an explanatory diagram for comparatively explaining a secular change in the power wave level and a secular change in the feedback command value.

[0034] As shown in an upper stage [A] of Fig. 3, the power wave level is stably maintained in the specified range by feedback control. Therefore, the power wave level falls out of the specified range only when an abnormality that cannot be covered by the feedback control occurs. It is therefore difficult for the malfunction diagnosis unit 124 to detect a sign of a malfunction such as natural deterioration only by monitoring the power wave level. When the malfunction diagnosis unit 124 detects an abnormality in the power wave level, it is necessary to perform malfunction coping (such as replacement of the onboard communication apparatus 1), which leads to causing troubles in the operation of a railroad train.

[0035] On the other hand, as shown in a lower stage [B] of Fig. 3, the feedback command value 126 gradually changes to compensate for a gradual deterioration phenomenon such as a reduction in transmission efficiency of the power waves. Therefore, the deterioration diagnosis unit 14 of the first embodiment monitors the information based on the feedback command value 126, so that even in a situation in which the power wave level is stabilized by the feedback control, the sign of the malfunction such as deterioration that may occur in the power wave transmission system can be grasped.

[0036] For example, the deterioration diagnosis unit 14 outputs the feedback command value 126 itself or feedback information calculated from the feedback command value 126 as deterioration information.

[0037] Also, for example, the deterioration diagnosis unit 14 makes a deterioration judgment when the feedback command value 126 exceeds a predetermined deterioration judgment threshold, and outputs a result of its deterioration judgment as deterioration information.

[0038] Further, for example, the deterioration diagnosis unit 14 accumulates the information based on the feedback command value 126 as a history and outputs the deterioration information when a change in the feedback command value 126 is detected.

[0039] In addition, for example, the deterioration diagnosis unit 14 estimates a progress situation of deterioration, based on the change over time of the feedback command value 126 and outputs an estimation result as deterioration information.

[Effects of First Embodiment]

[0040]

(1) In the first embodiment, the sign of the malfunction in the power wave transmission system can be detected based on the feedback command value 126.

(2) In the first embodiment, the deterioration diagnosis unit 14 detects the sign of the malfunction before the malfunction diagnosis unit 124 detects the malfunction. Therefore, maintenance such as replacement of the apparatus is made possible before the malfunction, thus improving the operation rate of the railroad vehicle.

(3) In the first embodiment, the deterioration diagnosis unit 14 transmits the feedback command value 126 itself or the feedback information calculated from the feedback command value to the host device 2 as the deterioration information. Therefore, in the host device 2 or the vehicle management center beyond that, it is possible to detect the sign of the malfunction in the power wave transmission system, based on the feedback command value 126 itself or the feedback information.

(4) In the first embodiment, the deterioration diagnosis unit 14 judges whether or not the feedback command value exceeds the deterioration judgement threshold, and outputs as the deterioration information, result of judgement that the feedback command value exceeds the deterioration judgement threshold. Therefore, the host device 2 or the vehicle management center beyond that does not receive the deterioration information in an unnecessary and/or non-urgent situation where the deterioration has not progressed, and receives the deterioration informa-

tion in a situation where the deterioration has progressed to some extent. As a result, there is an advantage that the burden of maintenance and management is reduced in the host device 2 or the vehicle management center beyond that.

(5) In the first embodiment, the deterioration diagnosis unit 14 accumulates the information based on the feedback command value 126 as a history and outputs the deterioration information at the time when the change in the feedback command value 126 is detected. Therefore, the host device 2 or the vehicle management center beyond that does not receive the deterioration information in an unnecessary and/or non-urgent situation where the deterioration has not progressed, and receives the deterioration information in a situation where the deterioration has progressed to some extent. As a result, there is an advantage that the burden of maintenance and management is reduced in the host device 2 or the vehicle management center beyond that.

(6) In the first embodiment, the deterioration diagnosis unit 14 estimates a progress situation of deterioration based on the change over time of the feedback command value 126 and outputs it as deterioration information. Therefore, the host device 2 or the vehicle management center beyond that does not need to estimate the progress situation of deterioration. As a result, there is an advantage that the burden of maintenance and management is reduced in the host device 2 or the vehicle management center beyond that.

(7) In the first embodiment, the information wave receiving unit 11 transmits the deterioration information to the host device 2 by using the same transmission path as the information wave telegram. Therefore, wiring for a new transmission path becomes unnecessary, and hence it becomes possible to reduce a circuit scale and eliminate the need for a circuit change.

<Second Embodiment>

[0041] Next, a second embodiment will be described in which deterioration diagnosis of a power wave sending system and deterioration diagnosis of an information wave reception system are performed.

[0042] Fig. 4 is a block diagram showing an onboard communication apparatus according to the second embodiment.

[0043] In the same figure, the onboard communication apparatus 1 includes a simulated information wave transmitting unit 16 in addition to the configuration described in the first embodiment (Fig. 1). Further, the onboard element 13 includes a power wave transmitting element 131 for sending the power waves to the ground element, a power wave monitoring antenna 132 for monitoring the state of sending of the power waves, an information wave receiving element 133 for receiving the information waves from the ground element, and a simulated information wave transmitting element 134 for sending simulated information waves from onboard.

[0044] Incidentally, in regard to other configurations, the same reference numerals as those in the first embodiment (Fig. 1) are attached, and dual explanations here will be omitted.

[0045] The host device 2 gives an instruction for a reception state test of the information waves to the simulated information wave transmitting unit 16. The simulated information wave transmitting unit 16 gives the simulated information wave transmitting element 134 simulated information waves which simulate the information waves from the ground element, in consideration of the timing when the information wave receiving unit 11 does not receive the information waves. The simulated information wave transmitting element 134 sends the simulated information waves to the information wave receiving element 133.

[0046] The information wave receiving unit 11 detects the simulated information waves received by the information wave receiving element 133 as information to be the basis of deterioration diagnosis such as a reception state, a reception level, frequency information, phase information, waveform distortion information, an attenuation amount, a noise amount, a signal-to-noise ratio (S/N), a carrier-to-noise ratio (C/N), a decoding information amount, a code error rate, a sideband wave amount, a modulation amount, a harmonic component amount, etc. and takes it to be deterioration information of the information wave reception system.

[0047] The information wave receiving unit 11 assigns to the deterioration information of the information wave reception system, an identifier denoting that effect and transmits it to the host device 2 by using the same transmission path as the information wave telegram.

[0048] Further, the power wave monitoring antenna 132 receives a part of the power waves transmitted from the power wave transmitting element 131 and outputs it to the deterioration diagnosis unit 14.

[0049] The deterioration diagnosis unit 14 detects the reception level of the power waves by the power wave monitoring antenna 132 and its change as information on the deterioration of the power wave transmission system. For example, the deterioration diagnosis unit 14 detects the deterioration of the power wave transmission system on the basis of a change in difference between the signal level of the power waves input to the onboard element and the reception level of the power waves by the power wave monitoring antenna 132, and outputs it as a kind of deterioration information.

[0050] The deterioration information of the power wave sending system detected by the deterioration diagnosis unit 14 is given an identifier denoting that effect, and is transmitted to the host device 2 by using the same transmission path as the information wave telegram.

[0051] Incidentally, since other operations are the same as those in the first embodiment, dual description

here will be omitted.

[Effects of Second Embodiment]

[0052] The second embodiment brings about the following effects in addition to the above-mentioned effects of first embodiment.

(1) In the second embodiment, the simulated information wave transmitting unit 16 sends the simulated information waves from the simulated information wave transmitting element 134, and the information wave receiving unit 11 receives the simulated information waves through the information wave receiving element 133, whereby the deterioration state (or failure state) of the information wave reception system can be detected.
(2) In the second embodiment, the deterioration diagnosis unit 14 outputs the state of deterioration (or failure state) of the power wave sending system, based on the change in the difference between the signal level of the power waves input to the onboard element and the reception level of the power waves by the power wave monitoring antenna. Thus, it is possible to detect a deterioration phenomenon such as the reception level of the power wave monitoring antenna 132 being reduced even though the signal level of the power waves input to the onboard element is sufficient.
(3) In the second embodiment, the deterioration diagnosis unit 14 monitors the part of the power waves through the power wave monitoring antenna 132 to thereby make it possible to detect the deterioration state (or failure state) of the power wave sending system.

<Third Embodiment>

[0053] Next, description will be made as to a third embodiment in which a logical part of an onboard communication apparatus is mounted in a program logic device (hereinafter referred to as "PLD") .

[0054] Fig. 5 is a block diagram showing the onboard communication apparatus according to the third embodiment.

[0055] In the same figure, the onboard communication apparatus 1 includes a PLD 17.

[0056] The PLD 17 installs therein a circuit configured by describing a program logic for a deterioration diagnosis unit 14, a level control part 121 which is at least a part of the feedback unit 12, an information wave control part 111 which is at least a part of the information wave receiving unit 11, and a malfunction diagnosis unit 124.

[0057] Incidentally, since other configurations are the same as those of the first embodiment (Fig. 2), dual description here will be omitted.

[Effects of Third Embodiment]

[0058] The third embodiment brings about the following effects in addition to the above-described effects of first embodiment.

[0059] (1) In the third embodiment, the deterioration diagnosis unit 14 and the input/output data paths to the deterioration diagnosis unit 14 are all included inside the PLD 17. Therefore, the present invention can be easily and inexpensively introduced into the conventional onboard communication apparatus by simply replacing the PLD of the onboard communication apparatus including the components excluding the deterioration diagnosis unit 14 with the PLD 17 of the third embodiment.

[0060] (2) Further, in the third embodiment, the present invention can also be easily and inexpensively introduced into the conventional onboard communication apparatus by simply adding the program logic that realizes the deterioration diagnosis unit 14 to the PLD of the onboard communication apparatus including the components excluding the deterioration diagnosis unit 14.

[0061] (3) Thus, in the third embodiment, it is possible to easily and inexpensively realize the onboard communication apparatus 1 of the third embodiment without the need for modifying the printed circuit board of the conventional onboard communication apparatus or adding parts.

<Fourth Embodiment>

[0062] Next, description will be made as to an operation of a fourth embodiment which acquires deterioration information at the timing of turning on (starting) the power of an onboard communication apparatus.

[0063] Incidentally, as for the apparatus configuration of the fourth embodiment, any of the apparatus configurations of the first to third embodiments can be adopted, and hence dual description of the configuration of the fourth embodiment will be omitted.

[0064] Fig. 6 is a flowchart showing a start-up sequence of the onboard communication apparatus according to the fourth embodiment.

[0065] Hereinafter, description will be made along Step numbers shown in the same figure.

[0066] Step S101: The onboard communication apparatus 1 performs initialization processing in response to power on. After the completion of the initialization processing, the feedback unit 12 starts the feedback control for transmitting the power waves.

[0067] Step S102: The malfunction diagnosis unit 124 acquires the power wave level as information from the feedback unit 12.

[0068] Step S103: The malfunction diagnosis unit 124 judges whether or not the power wave level is within the specified range defined by the feedback control. When the power wave level falls within the specified range, the malfunction diagnosis unit 124 shifts the operation to Step S105. On the other hand, when the power wave

level falls out of the specified range, the malfunction diagnosis unit 124 shifts the operation to Step S104.

[0069] Step S104: The malfunction diagnosis unit 124 stops the operation of the onboard communication apparatus 1 for the purpose of fail-safe because the power wave level deviates from the specified range despite the feedback control. Further, the malfunction diagnosis unit 124 stops an operation signal (clock) transferred from the onboard communication apparatus 1 to the host device 2. With the stop of this operation signal (clock), the host device 2 detects the operation stop (malfunction occurrence) of the onboard communication apparatus 1, and notifies a further host monitoring center or the like of a maintenance request for the onboard communication apparatus 1. As a result, the series of start-up sequence is interrupted here.

[0070] Step S105: Since the power wave level falls within the specified range, the malfunction diagnosis unit 124 continues the start-up sequence.

[0071] Subsequently, the deterioration diagnosis unit 14 judges whether or not the power wave level is in a stable state, based on an instantaneous fluctuation width of the feedback command value and the like. This is because, since the power wave level and the feedback command value 126 change instantaneously when the ground element 3 is close to the onboard element 13, that period is not suitable for detection of the deterioration information. If the power wave level is fluctuating, the deterioration diagnosis unit 14 waits for the operation until the ground element 3 separates from the onboard element 13 and the power wave level is stabilized. On the other hand, when the power wave level is in the stable state, the deterioration diagnosis unit 14 shifts the operation to Step S106.

[0072] Step S106: The deterioration diagnosis unit 14 acquires the feedback command value 126 as information from the feedback unit 12. The deterioration diagnosis unit 14 performs generation of deterioration information based on the feedback command value 126, or the like and outputs it to the information wave receiving unit 11.

[0073] Step S107: The information wave receiving unit 11 transmits the deterioration information based on the feedback command value 126 to the host device 2 by using the transmission path for the information wave telegram.

[0074] Step S108: The onboard communication apparatus 1 transmits the completion of the start-up sequence to the host device 2.

[0075] When the series of start-up sequence described above is completed, the operation is shifted to the normal operation of the railroad vehicle R.

[Effects of Fourth Embodiment]

[0076] The fourth embodiment brings about the following effects in addition to the effects of the first to third embodiments described above.

[0077] (1) In the fourth embodiment, the deterioration information is detected when the onboard communication apparatus 1 is started up, and transmitted to the host device 2. Therefore, the timing to transmit the deterioration information does not overlap with the reception timing of the information waves and the transmission timing of the information wave telegram. For that reason, it is possible to eliminate the risk that the timing of transmitting the information wave telegram of the information waves to the host device 2 is delayed or the reception of the information waves fails. Therefore, even if the operation of deterioration diagnosis is newly added, it is hard to interfere with the operation of the train.

[0078] (2) In the fourth embodiment, the deterioration information can be obtained each time the onboard communication apparatus 1 is started up. Normally, the railroad vehicle R repeats power-off and power-on at a frequency of once every operating day. Therefore, the deterioration information can be obtained at a frequency of once every operating day. Since the sign of the malfunction such as deterioration changes little by little over a long period of time, it can be said that the acquisition cycle of the deterioration information is sufficient about once a day.

<Fifth Embodiment>

[0079] Next, description will be made as to a fifth embodiment in which deterioration information is acquired at a timing instructed from the outside, and the deterioration information is further notified into a rack of a railroad vehicle R.

[0080] Fig. 7 is a diagram showing an onboard communication apparatus 1 according to the fifth embodiment.

[0081] A deterioration information request signal 18 is transferred from the host device 2 or the like to the deterioration diagnosis unit 14. Further, a switching signal for lighting display is transferred from the deterioration diagnosis unit 14 to an in-rack display 19.

[0082] Incidentally, since other configurations are the same as those in the first embodiment (Fig. 1), dual explanations here will be omitted.

[0083] In response to a request at any time from the deterioration information request signal 18, the deterioration diagnosis unit 14 detects the deterioration information and transmits it to the host device 2.

[0084] Further, when the deterioration diagnosis unit 14 judges deterioration (a sign of a malfunction) by the deterioration information, the display (LED or the like) indicating the deterioration of the in-rack display 19 is switched to an alarm state such as lighting or blinking.

[Effects of Fifth Embodiment]

[0085] The fifth embodiment brings about the following effects in addition to the above-described effects of first embodiment.

(1) In the fifth embodiment, the deterioration information can be acquired at any time at the timing of the deterioration information request signal 18 given from the outside. Thus, since the deterioration information can be acquired at any time at the timing matching the maintenance work of the railroad vehicle R, it is possible to detect deterioration (a sign of a malfunction) in timing with the maintenance work, and replace and maintain the onboard communication apparatus 1 and the like.

(2) In the fifth embodiment, the deterioration detection can be notified to the outside of the onboard communication apparatus 1. Therefore, it is possible to urge an operator and a maintenance worker of the railroad vehicle R to perform replacement of the onboard communication apparatus 1 and the like on a timely basis, so that the operation efficiency of the railroad vehicle R is improved.

[Supplementary matters of Embodiments]

[0086] Incidentally, the present invention is not limited to the above-mentioned embodiments, and includes various modifications. For example, the above-described first to fifth embodiments have been described in detail in order to explain the present invention in an easy-to-understand manner, and are not necessarily limited to those having all the configurations described.

[0087] Further, a part of the configuration of a certain embodiment can be replaced with the configuration of another embodiment. In addition, the configuration of a certain embodiment can also be combined with the configuration of another embodiment.

[0088] Furthermore, it is possible to add/delete/replace other configurations with respect to a part of the configuration of each embodiment.

[0089] Incidentally, in the above-described embodiment, the deterioration diagnosis unit 14 outputs the deterioration information based on the feedback command value 126. However, the present invention is not limited to this. The deterioration diagnosis unit 14 may output the deterioration information based on the feedback command value 126 in cooperation with a deterioration estimation function of the information wave control part 111, an external device, or the like.

[0090] Further, the configurations of the DDS 102, the variable attenuator 104, the power wave monitor 123, the A/D converter 112, the D/A converter 125, and the like shown in the above-described embodiment (see Fig. 2) are one of means. The present invention is not limited to these configurations. For example, instead of the DDS 102, a crystal oscillator and a low-pass filter may be used to generate a sine wave, or a power wave voltage may be divided without via the power wave monitor 123 and input to the A/D converter.

[0091] Also, the preamplifier 103, the preamplifier 113, the main amplifier 105, the low-pass filter 106, the band-pass filter 114, and the transformer 15 shown in the above-described embodiment (see Fig. 2) may be deleted if unnecessary. Further, in addition to those described in Fig. 2, a signal conversion circuit, a filter, etc. may be added as needed.

[0092] In addition, another deterioration diagnosis function may be added to the above-described embodiment. For example, when an information wave transmission circuit transmitting information waves to the ground element 3 via the onboard element 13 is provided, the deterioration diagnosis unit 14 detects the level information of the information waves output by the information wave transmission circuit to perform deterioration diagnosis, and may output it as deterioration information of a transmission system or a sending system of the information waves.

[0093] Incidentally, in the above-described embodiment, the internal configuration of the PLD 17 has been described, but the present invention is not limited to this. For example, a part of the power wave control part 101 or the information wave control part 111 may be mounted outside the PLD 17, or the A/D converter 112 may be provided inside the PLD 17.

[0094] Further, in the above-described embodiment, the start-up sequence of the onboard communication apparatus 1 shown in Fig. 6 has been described, but the present invention is not limited to this. For example, deterioration diagnosis is performed not only when the onboard communication apparatus 1 is started up, but at the timing when the information waves are not received, and the deterioration information is transmitted to the host device 2, so that it is possible for the information wave receiving unit 11 to avoid the competition of information (information wave telegram of information waves and deterioration information) to be transmitted to the host device 2.

[0095] Incidentally, in the above-described embodiment (see Fig. 7), the deterioration information request signal 18 is transmitted from the host device 2 to the deterioration diagnosis unit 14, but the present invention is not limited to this. For example, the deterioration information request signal 18 may be transmitted from the host device 2 to the deterioration diagnosis unit 14 through the power wave transmitting unit 10. Further, the deterioration information request signal (18) may be transmitted from the host device 2 to the information wave receiving unit 11.

[0096] Further, in the above-described embodiment (see Fig. 7), the example of notifying of the deterioration information by lighting or blinking the LED or the like has been described, but the present invention is not limited to this. For example, the deterioration diagnosis unit 14 may notify an external maintenance management device or the like of the deterioration information by using a wireless signal or a wired signal. Also, for example, the host device 2 may be provided with these display functions. In addition, the deterioration diagnosis unit 14 may transmit deterioration information to a specific ground element 3 via the onboard element 13.

[0097] Incidentally, in the above-described embodiment, the case of detecting the long-term deterioration phenomenon as the sign of the malfunction has been described, but the present invention is not limited to this. For example, the deterioration diagnosis unit 14 may quickly detect an acute deterioration phenomenon as a sign of a malfunction by destabilizing, changing, or oscillating of the feedback command value 126. Consequently, it is possible to diagnose the sign of the malfunction before the power wave level cannot be feedback-controlled in a short period of time and the malfunction occurs.

[0098] In addition, in the above-described embodiment, the deterioration information is output based on the absolute level of the feedback command value 126, but the present invention is not limited to this. The deterioration diagnosis unit 14 may obtain a difference (a margin for feedback control) between the limit value of the feedback command value 126 capable of feedback control and the feedback command value 126 and output deterioration information based on the margin for the feedback control.

[0099] Incidentally, in the above-described embodiment (see Fig. 5), the logical part of the onboard communication apparatus is implemented by the program logic device, but the present invention is not limited to this. For example, the logical part of the onboard communication apparatus may be realized by a computer system including a CPU (Central Processing Unit), a memory, and the like. By executing a program for deterioration diagnosis by this hardware, various deterioration diagnosis functions in the present invention are realized. A part or all of this hardware may be replaced with a DSP (Digital Signal Processor), an FPGA (Field-Programmable Gate Array), a GPU (Graphics Processing Unit), or the like. Further, the part or all of the hardware is centralized or distributed in a server on a network and arranged in a cloud. A plurality of onboard communication apparatuses (or host devices) may use in a joint manner, various types of deterioration diagnosis functions in the present invention via a wired or wireless network.

List of Reference Signs

[0100]

R railroad vehicle,
1 onboard communication apparatus,
2 host device,
10 power wave transmitting unit,
11 information wave receiving unit,
12 feedback unit,
13 onboard element,
14 deterioration diagnosis unit,
15 transformer,
16 simulated information wave transmitting unit,
17 program logic device (PLD),
18 deterioration information request signal,
19 in-rack display,
101 power wave control part,
102 DDS,
103 preamplifier,
104 variable attenuator,
105 main amplifier,
106 low-pass filter,
111 information wave control part,
112 A/D converter,
113 preamplifier,
114 bandpass filter,
121 level control part,
123 power wave monitor,
124 malfunction diagnosis unit,
125 D/A converter,
126 feedback command value,
131 power wave transmitting element,
132 power wave monitoring antenna,
133 information wave receiving element,
134 simulated information wave transmitting element.

Claims

1. An onboard communication apparatus which transmits power waves to and receives information waves from a ground element installed on a railroad track, the onboard communication apparatus comprising:

   a power wave transmitting unit which generates power waves;
   an onboard element which transmits the power waves generated by the power wave transmitting unit to the ground element and receives information waves transmitted by the ground element;
   a feedback unit which feeds back a feedback command value to the power wave transmitting unit, the feedback command value detecting output of the power waves to stabilize the output to a prescribed output; and
   a deterioration diagnosis unit which outputs information based on the feedback command value of the feedback unit as information indicating a sign of a malfunction (hereinafter "deterioration information").

2. The onboard communication apparatus according to claim 1, wherein the deterioration diagnosis unit outputs the feedback command value or feedback information calculated from the feedback command value as the deterioration information.

3. The onboard communication apparatus according to any one of claims 1 and 2, wherein the deterioration diagnosis unit judges whether or not the feedback command value exceeds a deterioration judgement threshold, and outputs as the deterioration in-

formation that the feedback command value exceeds the deterioration judgement threshold.

4. The onboard communication apparatus according to any one of claims 1 to 3, including an information wave receiving unit which demodulates the information waves received by the onboard element to generate an information wave telegram, and transmits the information wave telegram to a host device,
wherein the information wave receiving unit transmits the deterioration information output from the deterioration diagnosis unit to the host device by using the same transmission path as the information wave telegram.

5. The onboard communication apparatus according to any one of claims 1 to 4,

wherein the onboard element includes a simulated information wave transmitting unit which transmits simulated information waves, and
wherein the deterioration diagnosis unit outputs information based on reception of the simulated information waves by the onboard element as information regarding deterioration of a reception system of the information waves.

6. The onboard communication apparatus according to any one of claims 1 to 5,

wherein the onboard element includes a power wave monitoring antenna which receives at least a part of the power waves transmitted, and
wherein the deterioration diagnosis unit outputs information regarding deterioration of a transmission system of the power waves on the basis of a change in difference between a signal level of the power waves input to the onboard element and a reception level of the power waves by the power wave monitoring antenna.

7. The onboard communication apparatus according to any one of claims 1 to 6, wherein the deterioration diagnosis unit, at least a part of the feedback unit, and at least a part of the information wave receiving unit receiving the information waves are mounted in a programmable logic device.

8. The onboard communication apparatus according to any one of claims 1 to 7, wherein the deterioration diagnosis unit outputs the deterioration information after starting up of the onboard communication apparatus until a vehicle equipped with the onboard communication apparatus starts running.

9. The onboard communication apparatus according to any one of claims 1 to 8, wherein the deterioration diagnosis unit outputs the deterioration information when a deterioration information request signal is received.

10. The onboard communication apparatus according to any one of claims 1 to 9, wherein the deterioration diagnosis unit notifies the outside of deterioration based on the deterioration information.

11. An onboard communication apparatus which transmits power waves to and receives information waves from a ground element installed on a railroad track, the onboard communication apparatus comprising:

a power wave transmitting unit which transmits power waves;
an onboard element which transmits the power waves output by the power wave transmitting unit to the ground element and receives information waves transmitted by the ground element;
an information wave receiving unit which demodulates the information waves received by the onboard element to generate an information wave telegram and transmits the information wave telegram to a host device; and
a deterioration diagnosis unit which detects deterioration information for at least one of the power wave transmitting unit, the information wave receiving unit, and the onboard element,
wherein the information wave receiving unit transmits the deterioration information to the host device by using the same transmission path as the information wave telegram.

12. IA railroad vehicle comprising the onboard communication apparatus according to any one of claims 1 to 11.

1. An onboard communication apparatus which transmits power waves to and receives information waves from a ground element installed on a railroad track, the onboard communication apparatus comprising:

a power wave transmitting unit which generates power waves;
an onboard element which transmits the power waves generated by the power wave transmitting unit to the ground element and receives information waves transmitted by the ground element;
a feedback unit which feeds back a feedback command value for detecting output of the power waves and stabilizing the output to a prescribed output to the power wave transmitting unit; and
a deterioration diagnosis unit which outputs information based on the feedback com-

mand value of the feedback unit as information indicating a sign of a malfunction (hereinafter "deterioration information"),
wherein the onboard element includes a simulated information wave transmitting unit which transmits simulated information waves, and
wherein the deterioration diagnosis unit outputs information based on reception of the simulated information waves by the onboard element as information regarding deterioration of a reception system of the information waves.

2. The onboard communication apparatus according to claim 1, wherein the deterioration diagnosis unit outputs the feedback command value or feedback information calculated from the feedback command value as the deterioration information.

3. The onboard communication apparatus according to any one of claims 1 and 2, wherein the deterioration diagnosis unit judges whether or not the feedback command value exceeds a deterioration judgement threshold, and outputs as the deterioration information that the feedback command value exceeds the deterioration judgement threshold.

4. The onboard communication apparatus according to any one of claims 1 to 3, including an information wave receiving unit which demodulates the information waves received by the onboard element to generate an information wave telegram, and transmits the information wave telegram to a host device,
wherein the information wave receiving unit transmits the deterioration information output from the deterioration diagnosis unit to the host device by using the same transmission path as the information wave telegram.

5. The onboard communication apparatus according to any one of claims 1 to 4,

wherein the onboard element includes a power wave monitoring antenna which receives at least a part of the power waves transmitted, and
wherein the deterioration diagnosis unit outputs information regarding deterioration of a transmission system of the power waves on the basis of a change in difference between a signal level of the power waves input to the onboard element and a reception level of the power waves by the power wave monitoring antenna.

6. The onboard communication apparatus according to any one of claims 1 to 4 and 5, wherein the deterioration diagnosis unit, at least a part of the feedback unit, and at least a part of the information wave receiving unit receiving the information waves are mounted in a programmable logic device.

7. The onboard communication apparatus according to any one of claims 1 to 4 and claims 5 to 6, wherein the deterioration diagnosis unit outputs the deterioration information after starting up of the onboard communication apparatus until a vehicle equipped with the onboard communication apparatus starts running.

8. The onboard communication apparatus according to any one of claims 1 to 4 and claims 5 to 7, wherein the deterioration diagnosis unit outputs the deterioration information when a deterioration information request signal is received.

9. The onboard communication apparatus according to any one of claims 1 to 4 and claims 5 to 8, wherein the deterioration diagnosis unit notifies the outside of deterioration based on the deterioration information.

10. An onboard communication apparatus which transmits power waves to and receives information waves from a ground element installed on a railroad track, the onboard communication apparatus comprising:

a power wave transmitting unit which transmits power waves;
an onboard element which transmits the power waves output by the power wave transmitting unit to the ground element and receives information waves transmitted by the ground element;
an information wave receiving unit which demodulates the information waves received by the onboard element to generate an information wave telegram and transmits the information wave telegram to a host device; and
a deterioration diagnosis unit which detects deterioration information for at least one of the power wave transmitting unit, the information wave receiving unit, and the onboard element,
wherein the information wave receiving unit transmits the deterioration information to the host device by using the same transmission path as the information wave telegram,
wherein the onboard element includes a simulated information wave transmitting unit which transmits simulated information waves, and
wherein the deterioration diagnosis unit outputs information based on reception of the simulated information waves by the on-

board element as information regarding deterioration of a reception system of the information waves.

11. A railroad vehicle comprising the onboard communication apparatus according to any one of claims 1 to 4 and claims 5 to 10.

FIG.1

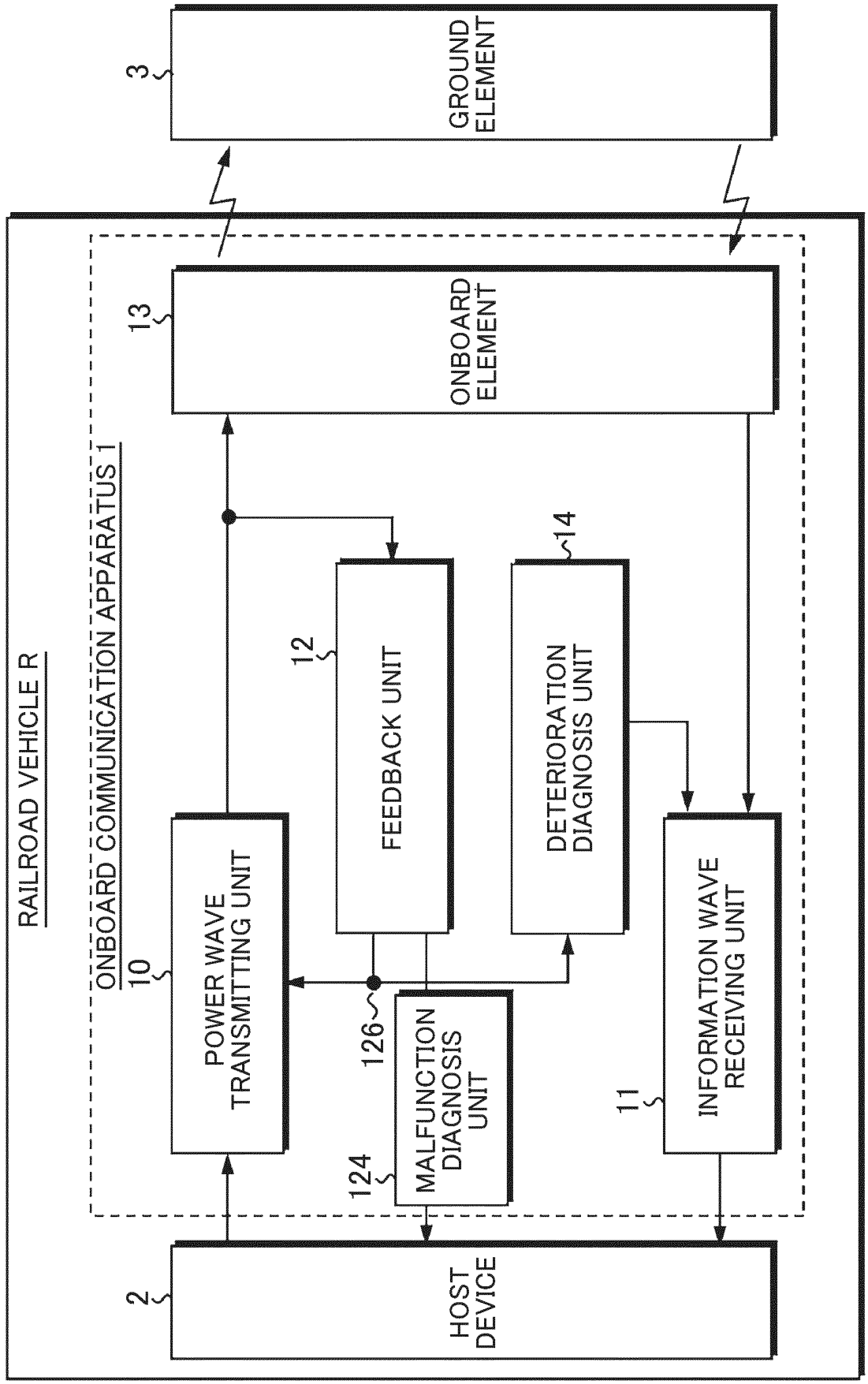

3
GROUND ELEMENT
RAILROAD VEHICLE R
ONBOARD COMMUNICATION APPARATUS 1
13
ONBOARD ELEMENT
12
FEEDBACK UNIT
14
DETERIORATION DIAGNOSIS UNIT
10
POWER WAVE TRANSMITTING UNIT
126
124
MALFUNCTION DIAGNOSIS UNIT
11
INFORMATION WAVE RECEIVING UNIT
2
HOST DEVICE

FIG.2

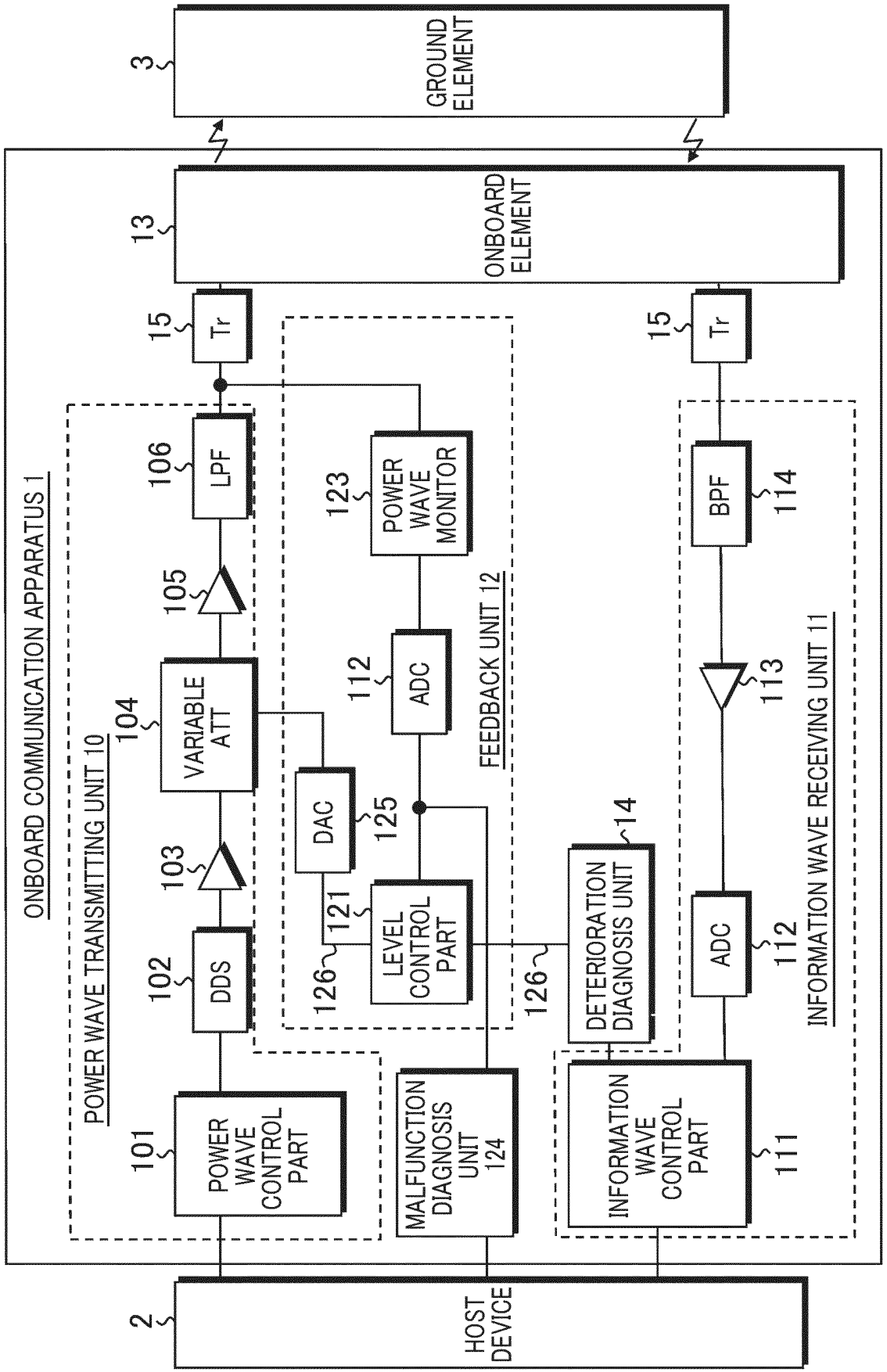

3
GROUND ELEMENT
13
ONBOARD ELEMENT
ONBOARD COMMUNICATION APPARATUS 1
POWER WAVE TRANSMITTING UNIT 10
FEEDBACK UNIT 12
INFORMATION WAVE RECEIVING UNIT 11
15
Tr
15
Tr
106
LPF
105
104
VARIABLE ATT
103
102
DDS
101
POWER WAVE CONTROL PART
123
POWER WAVE MONITOR
112
ADC
DAC
125
121
126
LEVEL CONTROL PART
MALFUNCTION DIAGNOSIS UNIT 124
126
14
DETERIORATION DIAGNOSIS UNIT
INFORMATION WAVE CONTROL PART
111
BPF
114
113
ADC
112
2
HOST DEVICE

FIG.3

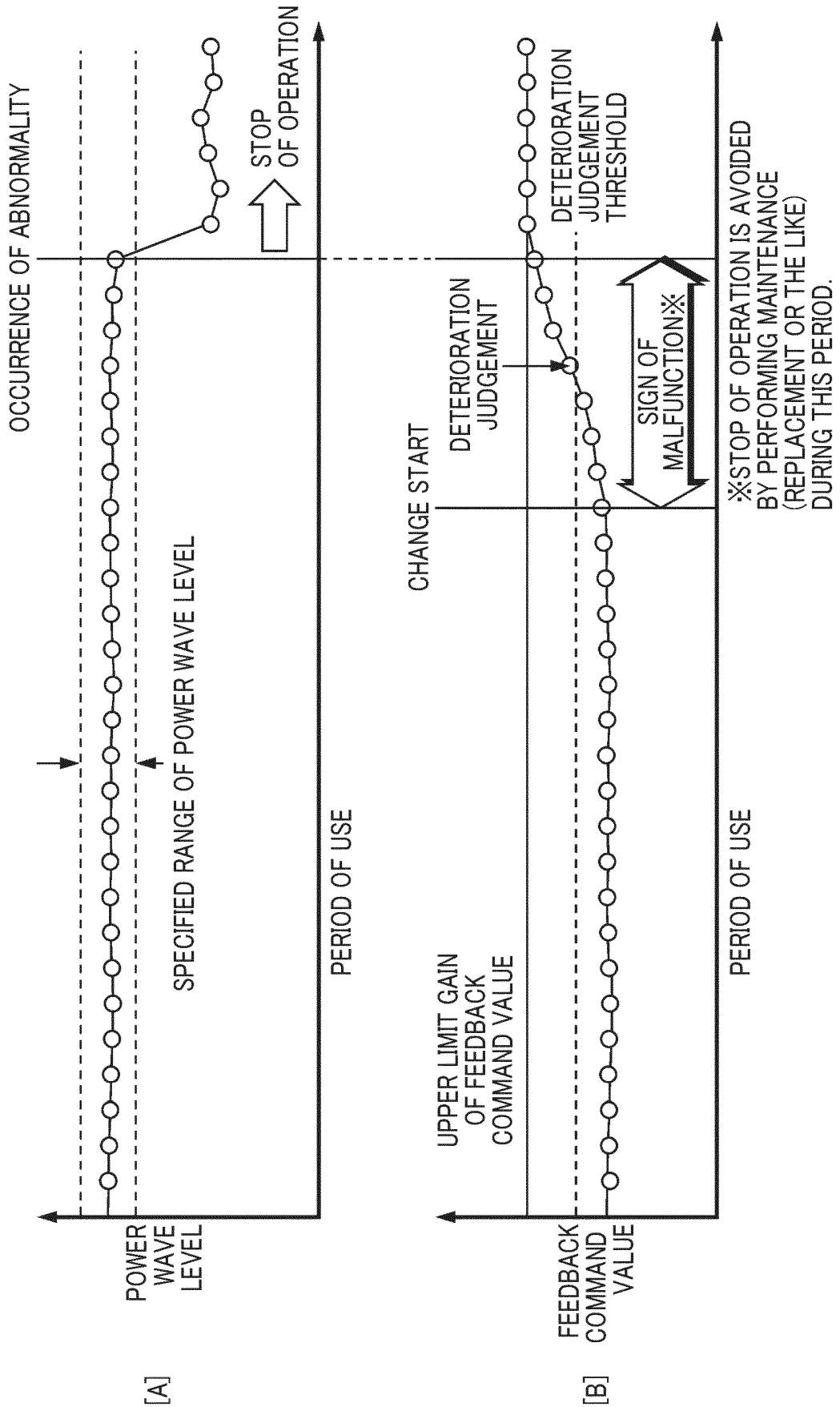

[A]
POWER WAVE LEVEL
OCCURRENCE OF ABNORMALITY
SPECIFIED RANGE OF POWER WAVE LEVEL
STOP OF OPERATION
PERIOD OF USE
[B]
FEEDBACK COMMAND VALUE
UPPER LIMIT GAIN OF FEEDBACK COMMAND VALUE
CHANGE START
DETERIORATION JUDGEMENT
DETERIORATION JUDGEMENT THRESHOLD
SIGN OF MALFUNCTION※
※STOP OF OPERATION IS AVOIDED BY PERFORMING MAINTENANCE (REPLACEMENT OR THE LIKE) DURING THIS PERIOD.
PERIOD OF USE

FIG.4

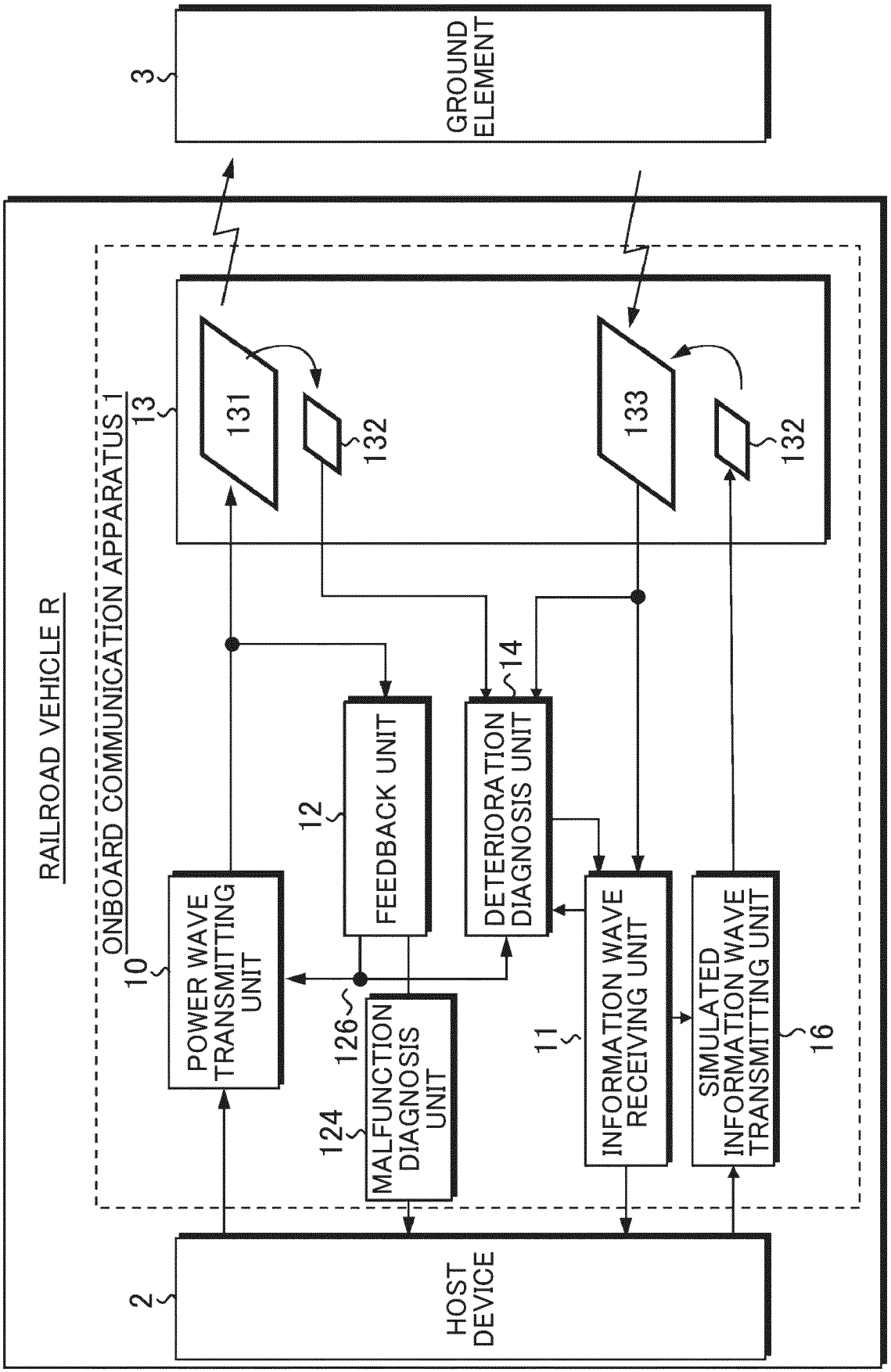

3
GROUND ELEMENT
RAILROAD VEHICLE R
ONBOARD COMMUNICATION APPARATUS 1
13
131
132
133
132
14
12
FEEDBACK UNIT
DETERIORATION DIAGNOSIS UNIT
10
POWER WAVE TRANSMITTING UNIT
126
124
MALFUNCTION DIAGNOSIS UNIT
11
INFORMATION WAVE RECEIVING UNIT
SIMULATED INFORMATION WAVE TRANSMITTING UNIT
16
2
HOST DEVICE

FIG.5

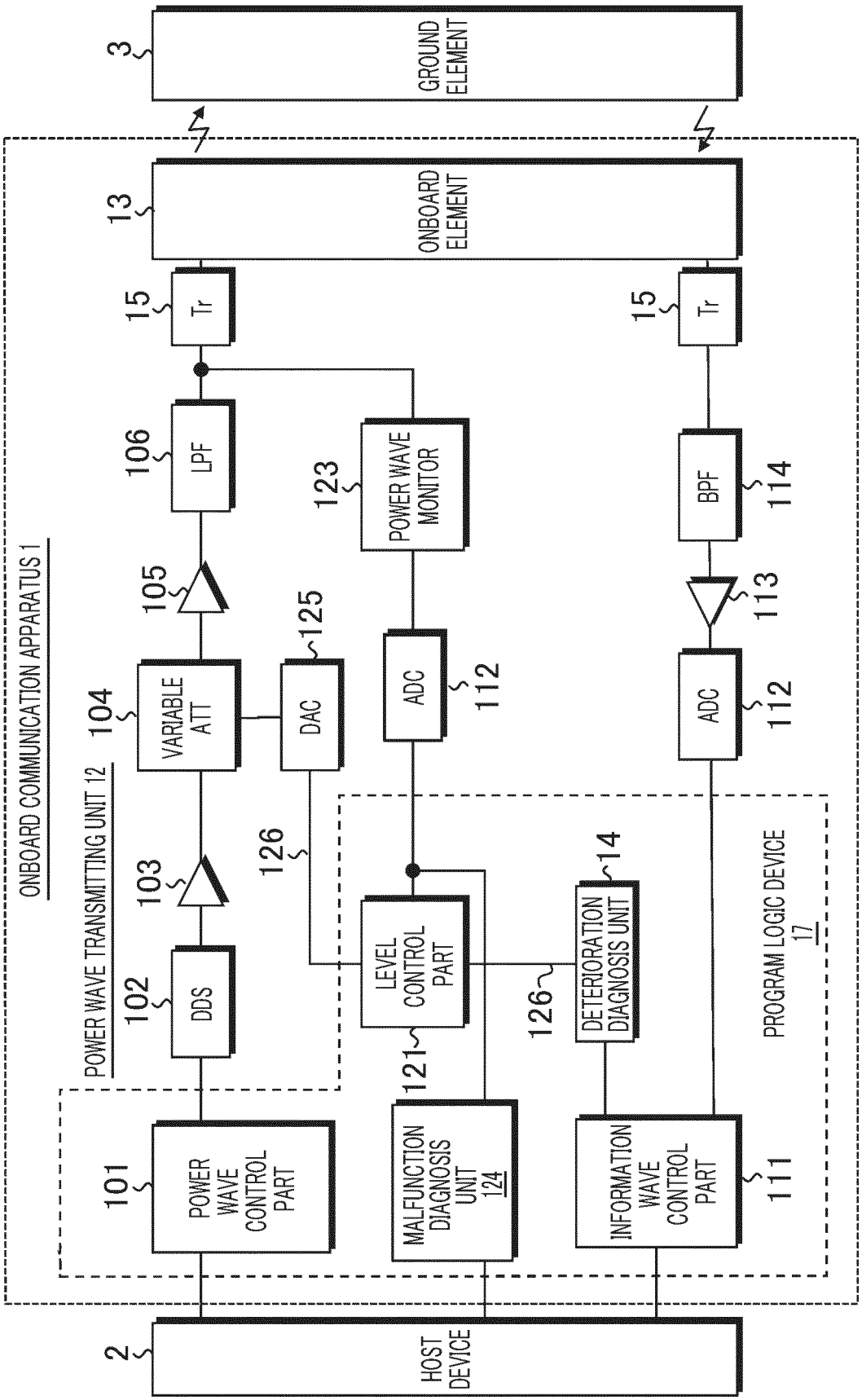

3
GROUND ELEMENT
13
ONBOARD ELEMENT
15
Tr
15
Tr
106
LPF
123
POWER WAVE MONITOR
BPF
114
105
113
125
104
VARIABLE ATT
DAC
ADC
112
ADC
112
ONBOARD COMMUNICATION APPARATUS 1
POWER WAVE TRANSMITTING UNIT 12
103
126
14
102
DDS
LEVEL CONTROL PART
DETERIORATION DIAGNOSIS UNIT
126
PROGRAM LOGIC DEVICE
17
121
101
POWER WAVE CONTROL PART
MALFUNCTION DIAGNOSIS UNIT
124
INFORMATION WAVE CONTROL PART
111
2
HOST DEVICE

FIG.6

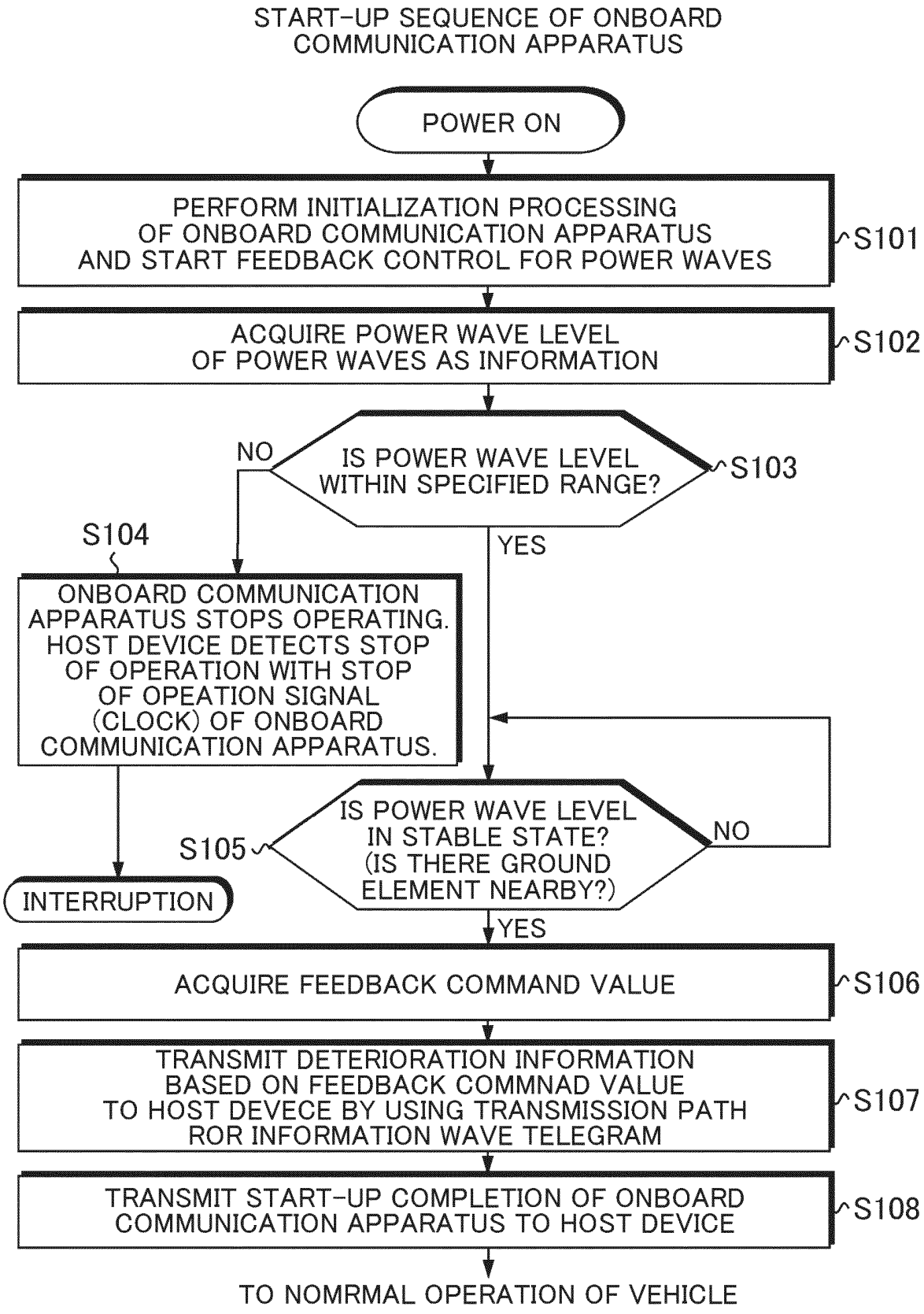
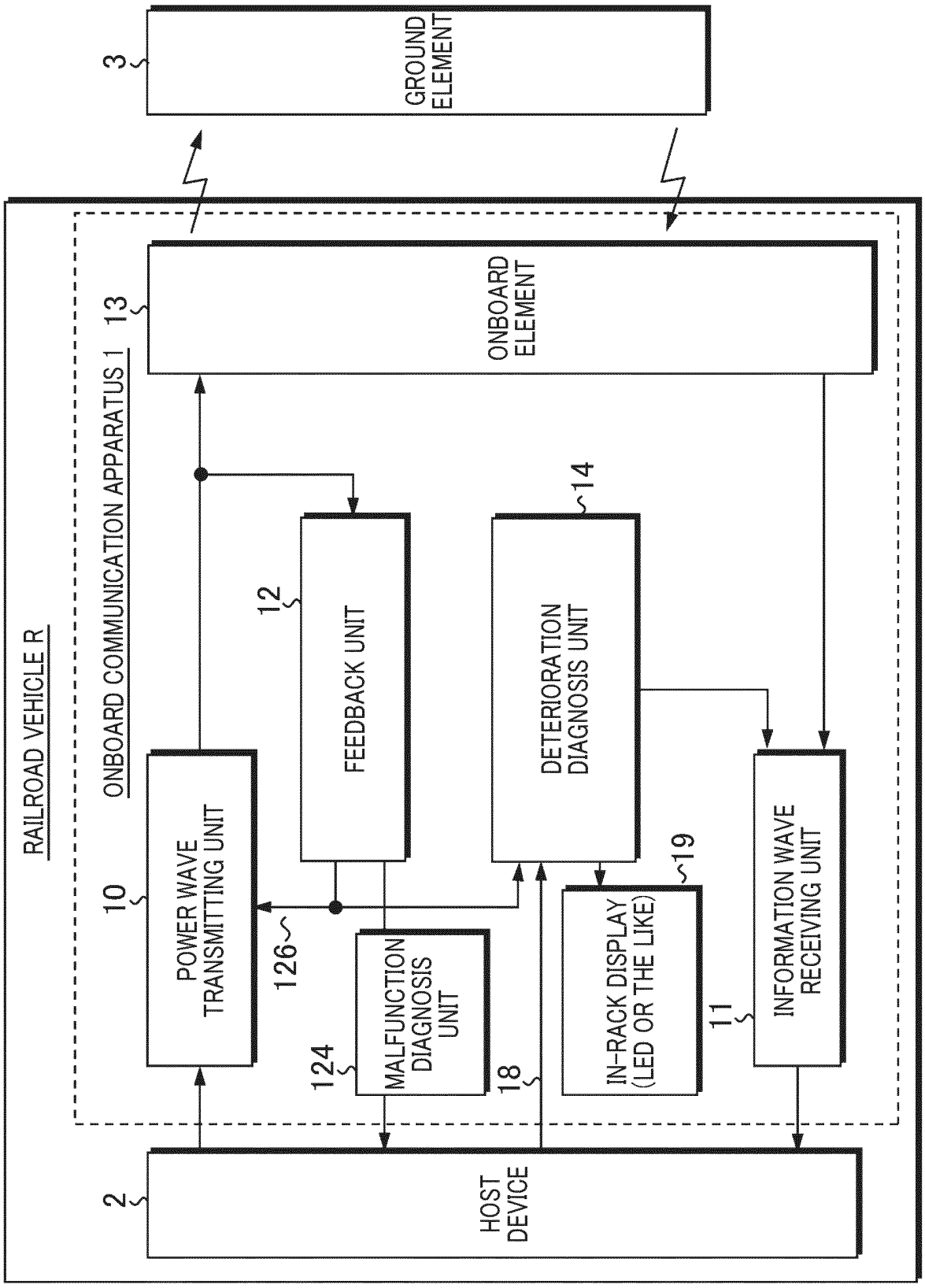

START-UP SEQUENCE OF ONBOARD COMMUNICATION APPARATUS
POWER ON
PERFORM INITIALIZATION PROCESSING OF ONBOARD COMMUNICATION APPARATUS AND START FEEDBACK CONTROL FOR POWER WAVES
S101
ACQUIRE POWER WAVE LEVEL OF POWER WAVES AS INFORMATION
S102
IS POWER WAVE LEVEL WITHIN SPECIFIED RANGE?
S103
NO
YES
S104
ONBOARD COMMUNICATION APPARATUS STOPS OPERATING. HOST DEVICE DETECTS STOP OF OPERATION WITH STOP OF OPEATION SIGNAL (CLOCK) OF ONBOARD COMMUNICATION APPARATUS.
INTERRUPTION
IS POWER WAVE LEVEL IN STABLE STATE? (IS THERE GROUND ELEMENT NEARBY?)
S105
NO
YES
ACQUIRE FEEDBACK COMMAND VALUE
S106
TRANSMIT DETERIORATION INFORMATION BASED ON FEEDBACK COMMNAD VALUE TO HOST DEVECE BY USING TRANSMISSION PATH ROR INFORMATION WAVE TELEGRAM
S107
TRANSMIT START-UP COMPLETION OF ONBOARD COMMUNICATION APPARATUS TO HOST DEVICE
S108
TO NOMRMAL OPERATION OF VEHICLE

FIG.7


3
GROUND ELEMENT
RAILROAD VEHICLE R
ONBOARD COMMUNICATION APPARATUS 1
13
ONBOARD ELEMENT
12
FEEDBACK UNIT
14
DETERIORATION DIAGNOSIS UNIT
10
POWER WAVE TRANSMITTING UNIT
126
124
MALFUNCTION DIAGNOSIS UNIT
18
19
IN-RACK DISPLAY (LED OR THE LIKE)
11
INFORMATION WAVE RECEIVING UNIT
2
HOST DEVICE

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/046135

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. B61L3/12(2006.01)i, B61L23/14(2006.01)i, H04B17/19(2015.01)i, B60L3/00(2019.01)i
FI: B61L3/12Z, H04B17/19, B61L23/14E, B60L3/00N
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)
Int.Cl. B61L3/12, B61L23/14, H04B17/19, B60L3/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2020
Registered utility model specifications of Japan 1996-2020
Published registered utility model applications of Japan 1994-2020

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.
Y A	JP 2017-195486 A (HITACHI, LTD.) 26.10.2017 (2017-10-26), paragraphs [0013]-[0044], fig. 1-4	1-4, 6-12 5
Y A	JP 4-305794 A (TOSHIBA CORPORATION) 28.10.1992 (1992-10-28), paragraphs [0002]-[0008], fig. 4	1-4, 6-12 5

☐ Further documents are listed in the continuation of Box C.
☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28.01.2020	10.02.2020

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2019/046135

JP 2017-195486 A	26.10.2017	(Family: none)	
JP 4-305794 A	28.10.1992	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

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 2017195486 A **[0006]**