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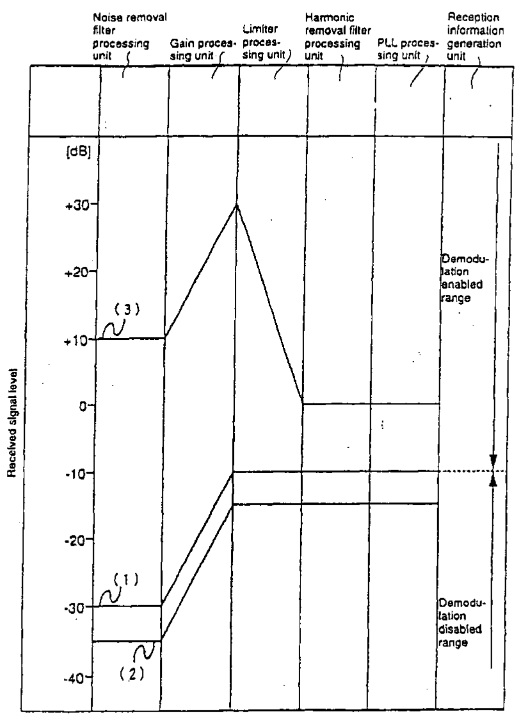
(54) METHOD AND DEVICE FOR RECEIVING FREQUENCY-MODULATED SIGNAL

(57) The object of the present invention is to provide a train detection system which is highly resistant to noise. In a method for using a frequency modulated signal as a train detection signal and judging train decision by existence of demodulation due to a reduction in the received signal level caused by a short-circuit of the axle, as a method for optionally setting a threshold value of train decision, when applying the amplitude-dependent demodulation process, by combining the gain process of amplifying the amplitude of a signal, the limiter process of limiting the amplitude of the output signal of the gain process to a fixed value, and the filter process of removing harmonics generated by the limiter process at the previous stage of the demodulation process and by optionally setting the lower limit value of the demodulatable signal level by the gain, a process of optionally setting a threshold value of train decision is realized.

Fig. 2



EP 1 115 213 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a signal receiver using the demodulation process of a frequency modulated signal dependent on the amplitude and more particularly to a train detector using track circuits of a railroad.

BACKGROUND OF THE INVENTION

[0002] In signal control of a railroad, as a method for detecting a train, there is a method for electrically splitting each of both railroad tracks into sections called track circuits and detecting existence of a train for each track circuit. In such track circuits, one end of each track circuit sends a signal, and the other end receives the signal, and using that when there is a train within the target track circuit, the wheels of the train short-circuit the left and right tracks and the received signal lowers in the level, level changes of the received signal are observed and existence of a train is decided by comparing the receiving level with an optional threshold value for deciding existence of a train.

[0003] The receiving level is affected by a length difference of each track circuit and the ambient environment, and the levels when there is no train are also different from each other, and the effect statuses caused to the receiving level by a short-circuit by the wheels of a train are also different from each other, so that it is necessary to make it possible to individually set an optional threshold value for each track circuit.

[0004] The receiving level value is affected by all signal components in the frequency band decided by the filter characteristic, so that when there are other devices using the neighboring frequency band, it is difficult to eliminate effects as noises of signals used by those devices. When the effect of such noises is strong, for example, although there is a train within the target track circuit, when the received signal level becomes larger than the train detection level due to the effect of noises, there is the possibility that the decision of existence of a train may be wrong.

[0005] A method for using a frequency modulated signal as such a signal for detecting a train is described in Japanese Patent Application Laid-Open 9-125261.

[0006] According to this application, when a frequency modulated signal is used, existence of a train can be decided using correctness or incorrectness of information included in the received signal in addition to the received signal level, so that whether it is noise or not can be decided more precisely.

[0007] However, with respect to a received signal, the condition varying with existence of a train is only the level change of the received signal. Therefore, when a frequency modulated signal is to be used, to perform the demodulation process by the receiver, it is necessary to use a demodulation method having amplitude dependency for deciding whether or not to demodulate depending on changing of the amplitude. As a demodulation processing method satisfying such a condition, for example, a method using the PLL process may be considered. In the PLL process, the amplitude of an input signal is preset at the time of design, and when the input amplitude becomes smaller, the synchronous frequency range becomes smaller, and when this frequency range cannot satisfy the modulation range of the frequency modulated signal, it is quantitatively indicated that the synchronization condition cannot be satisfied. From this, the lower level of demodulation which is the received signal level when the synchronization condition cannot be satisfied and the frequency cannot be demodulated can be obtained by calculation and the PLL process is designed so as to coincide the train detection level with the lower level of demodulation.

[0008] However, the train detection level varies with the track circuit, so that it is also necessary to individually set the lower level of demodulation for each track circuit. However, it is actually difficult in respect of productivity to generate a PLL process in which the lower level of demodulation is individually set for all the track circuits.

EXPLANATION OF THE PREFERRED EMBODIMENTS

[0009] An object of the present invention is to improve the productivity of a train detector which is more resistant to noise.

[0010] The above object is accomplished by use of a method for performing a demodulation process dependent on the amplitude for demodulation and optionally setting -the train detection level which is a threshold value of the signal level for train decision, and by performing the gain process of amplifying the amplitude of a signal, the limiter process of limiting the amplitude of the output signal of the gain process to a fixed value equal to the design input amplitude of the demodulation process, and the filter process of removing harmonics generated by the limiter process at the previous stage of the demodulation process when applying the demodulation process, and by setting the lower limit value of the demodulatable signal level to the same value as the train detection level by changing the gain value.

[0011] Furthermore, by setting the sampling frequency of the filter process to a multiple of one-to-an-odd-number of the sampling frequency for the frequency to be processed, by setting the pass band of the filter to a value wider than the signal band necessary for demodulation, and by setting the pass band to one-to-an-odd-number of the sampling frequency, the effect of the harmonics of an odd degree among the harmonics generated by the limiter process can be removed most efficiently. By doing this, an increase in the processing amount of the whole receiving process due to an increase in the filter process can be reduced.

[0012] Furthermore, the productivity of a train detector which is highly resistant to noise can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Fig. 1 is a drawing showing the constitution of a train detector of an embodiment of the present invention.

[0014] Fig. 2 is a drawing showing the relationship between the process constitution of a receiver and the received signal level of an embodiment of the present invention.

[0015] Fig. 3 is a drawing showing the relationship of the input level and output level of the limiter process to the design value of input amplitude of the PLL process of an embodiment of the present invention.

[0016] Fig. 4 is a drawing showing the relationship between the train detection level and the possibility of demodulation of an embodiment of the present invention.

[0017] Fig. 5 is a drawing showing the frequency characteristic of the filter process of an embodiment of the present invention.

[0018] Fig. 6 is a drawing showing the relationship between the frequency characteristic of the filter process and harmonics of an odd degree of an embodiment of the present invention.

[0019] Fig. 7 is an embodiment when the present invention is applied to a plurality of track circuits.

[0020] Fig. 8 is a drawing showing the equipment constitution when the present invention is applied to a water quality detector in a water bath.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0021] An embodiment of the present invention will be explained hereunder. In this case, an example that a receiver of a train detector using track circuits of a railroad is considered as a device to which the present invention is applied and the PLL process is used as a frequency modulated signal demodulation process depending on the. amplitude will be explained.

[0022] Fig. 1 shows the system constitution of this system. Each of the tracks on which a train runs comprises one or more track circuits. With respect to each track circuit, a transmitter 2 for transmitting a train detection signal which is a frequency modulated signal is connected to one end thereof and a receiver 3 for receiving the train detection signal is connected to the other end. A train detector 1 is connected to the transmitter and receiver via a transmission line such as a network.

[0023] Before explaining the outline of processes between the devices of this system, the principle of the process executed by this system will be explained.

[0024] When the train exists within the range of a track circuit, the tracks are short-circuited by the wheels of the train. Therefore, the received signal level of the train detection signal received by the receiver is lower than that when the train does not exist within the range of the track circuit. In this case, the received signal level when it lowers and becomes the threshold value when the signal judges existence of a train is called a train detection level.

[0025] It is necessary to set the train detection level to an optional value for each track circuit. Therefore, as a method for optionally setting the lower limit level of demodulation which is a lower limit value which can be demodulated according to the train detection level individually for each track circuit, the gain processing unit, limiter processing unit, and harmonic removal filter processing unit perform processing in this order at the previous stage of the PLL processing unit.

[0026] Firstly, the gain processing unit amplifies the signal so as to coincide the train detection level with the lower level of demodulation and receives the amplification factor necessary for signal amplification from the gain information holding unit as gain information.

[0027] The limiter processing unit restricts the amplitude so as to prevent the PLL processing unit from receiving excessive input due to the amplification factor.

[0028] The harmonic removal filter processing unit removes the harmonic component generated by the limiter process.

[0029] A train is detected according to the following procedure. Firstly, the transmission information generation unit of the train detector generates transmission information and transmits it to the transmitter via the network. This transmission information is also sent to the reception information check unit in the train detector.

[0030] Next, the transmitter converts the transmission information received via the network to a train detection signal in the frequency modulation processing unit and transmits it to the track circuit.

[0031] The receiver 3 firstly removes noise included in the received signal from the train detection signal received via the track circuit by a noise removal filter processing unit 31. Next, the receiver 3 amplifies the received signal by a gain processing unit 32 using the gain information from a gain information holding unit 33. Next, a limiter processing unit 34 restricts the amplitude of the received signal. Next, a harmonic component removal filter processing unit 35 removes the harmonic component included in the train detection signal. Next, a PLL processing unit 36 detects the modulation component of the received train detection signal. Finally, a reception information generation unit 37 generates reception information from the modulation component and transmits it to the train detector via the transmission line such as the network.

[0032] Finally, the train detector checks the transmission information and reception information in the reception information check unit, detects existence of a train within the range of the track circuit, gives and displays the detection result on the display unit, and also sends the signal to the signal control unit so as to control it.

[0033] Fig. 2 shows a level diagram regarding the relationship between the received signal level and the lower level of demodulation. Firstly, the procedure for coinciding the train detection level with the lower level of demodulation is shown. It corresponds to the characteristic (1) shown in Fig. 2. The characteristic of the PLL processing unit depends on the amplitude of a received signal which is an input signal to the PLL process, so that the PLL processing unit is designed by deciding the amplitude of an input signal first and the lower level of demodulation is derived. For example, it is assumed that when the PLL processing unit is designed assuming the amplitude of an input signal as 1.0, the lower level of demodulation is 0.316. In this case, assuming that the design value 1.0 of the amplitude of input signal is 0 [dB] in level, the PLL process can demodulate a signal level of -10 [dB] or higher.

[0034] For the received signal, the gain processing unit firstly sets the amplification factor for coinciding the lower level of demodulation of the PLL process with the train detection level for each track circuit and holds it in the gain information holding unit as gain information. For example, assuming that the receiving level when no train exists within the range of the track circuit is 3.16 (equivalent to +10 [dB]) and the amplitude on the train detection level is 0.0316 (equivalent to -30 [dB]), since the lower level of demodulation is 0.316 (-10 [dB]), it is desirable to set 10.0 (equivalent to +20 [dB]) as gain information.

[0035] The limiter processing unit restricts the amplitude of the received signal to which the amplification factor is added by the gain processing unit and sets it to a value such that the maximum amplitude of the input signal of the PLL processing unit coincides with the amplitude at the time of design of the PLL processing unit. For example, when the amplitude on the train detection level is 0.0316 (-30 [dB]), and the lower level of demodulation is 0.316 (-10 [dB]), and the amplification factor is 10.0 (+20 [dB]) and when the receiving level when no train exists within the range of the track circuit is 3.16 (+10 [dB]), the amplitude of an output signal of the gain processing unit is 3.16 (+30 [dB]). On the other hand, the set value of input amplitude of the PLL processing unit is 1.0 (0 [dB]), so that the input level is excessively high and it is difficult for the PLL processing unit to operate according to the design value. On the other hand, the limiter processing unit controls a value beyond 1.0 (0 [dB]) which is a set value of input amplitude of the PLL processing unit to 1.0 (0 [dB]) so as to avoid excessive level input to the PLL processing unit. As a result, with respect to the relationship between the input amplitude and the output amplitude of the limiter processing unit, within the range below the amplitude at the time of design of the PLL processing unit, the input amplitude is equal to the output amplitude and in the case of more than the amplitude at the time of design of the PLL processing unit, the output amplitude is equal to the amplitude at the time of design of the PLL processing unit. This relationship is shown in Fig. 3.

[0036] The harmonic removal filter processing unit removes harmonics generated by the limiter processing unit. An output signal of the limiter processing unit is close to a square wave when the receiving level is more than the amplitude at the time of design of the PLL processing unit, so that it includes a harmonic component. When the output signal of the limiter processing unit is inputted to the PLL processing unit in the state of including harmonics, the harmonic component affects the PLL processing unit as a noise component and the PLL processing unit cannot satisfy the designed characteristic. Therefore, the harmonic removal filter processing unit removes the harmonic component so that the PLL processing unit processes according to the design.

[0037] As a result, the PLL processing unit can receive an input signal in which the lower level of demodulation coincides with the train detection level.

[0038] Next, a case that a train exists within the range of the track circuit and a case that no train exists will be considered. For example, cases that the amplitude on the train detection level is 0.0316 (-30 [dB]), and the amplification factor is 10.0 (+20 [dB]), and the set value of input amplitude at the time of design of the PLL processing unit is 1.0 (0 [dB]), and the lower level of demodulation is 0.316 (-10 [dB]) will be described respectively.

[0039] Firstly, a case that a train exists on a pair of track circuits is considered. For example, it is assumed that the receiving level is 0.0177 (-35 [dB]). The characteristic at this time is equivalent to (2) shown in Fig. 2. The receiving level is a value smaller than a train detection level of 0.0316. At this time, the output of the gain processing unit is 0.177 (-15 [dB]), which is a smaller value than 0.316 (-10 [dB]).

[0040] On the other hand, the maximum value of output amplitude of the limiter processing unit is 1.0 (0 [dB]) which is a value equal to the set value of input amplitude of the PLL processing unit, so that the output of the gain processing unit is not affected by it. Therefore, no harmonic component is generated in the output of the limiter processing unit, so that the harmonic removal filter processing unit is neither affected. As a result, a signal of 0.177 (-15 [dB]) which is a signal of a smaller level than the amplitude 0.316 (-10 [dB]) is inputted to the PLL processing unit. On the other hand, the lower level of demodulation of the PLL processing unit is 0.316 (-10 [dB]), so that the frequency cannot be demodulated. Namely, a signal with an amplitude smaller than the train detection level is not demodulated. Therefore, the reception information generation unit does not generate reception information, so that the transmission information does not coincide with the reception information in the reception information check unit of the train detector and the existence of a train on the track circuits can be detected.

[0041] Next, a case that no train exists on a pair of track circuits is considered. For example, it is assumed that the receiving level is 3.16 (+10 [dB]). The characteristic at this time is equivalent to (3) shown in Fig. 2. The receiving level is a value larger than a train detection level of 0.0316 (-30 [dB]). At this time, the output of the gain processing unit is 3.16 (+30 [dB]) which is a larger value than 0.316 (-10 [dB]). On the other hand, the maximum value of output amplitude of the limiter processing unit is 1.0 (0 [dB]) which is a value equal to the set value of input amplitude of the PLL processing unit, so that the level higher than 1.0 (0 [dB]) among the output of the gain processing unit is affected, and the amplitude is restricted, and the output signal of the limiter processing unit becomes a signal similar to a square wave, and the amplitude thereof is 1.0 (0 [dB]). As a result, a harmonic component is included in the output of the limiter processing unit. However, since the harmonic component is removed by the harmonic removal filter processing unit, the output signal of the harmonic removal filter processing unit is a signal from which the harmonics are removed, and the amplitude is the same as that of the output signal of the limiter processing unit, and the maximum value thereof is 1.0 (0 [dB]). As a result, a signal with an amplitude which is larger than 0.316 (-10 [dB]) and smaller than 1.0 (0 [dB]) is inputted to the PLL processing unit. On the other hand, the lower level of demodulation of the PLL processing unit is 0.316 (-10 [dB]) and the set value of input amplitude of the PLL processing unit is 1.0 (0 [dB]), so that the frequency can be demodulated. Namely, a signal with an amplitude larger than the train detection level is demodulated. Therefore, the reception information generation unit generates reception information, so that the transmission information coincides with the reception information in the reception information check unit of the train detector. From this, non-existence of a train on the track circuits can be detected.

[0042] Namely, it can be quantitatively indicated that a signal level lower than the train detection level is not demodulated and a signal level higher than the train detection level is demodulated. As mentioned above, by using a method for providing the gain processing unit, limiter processing unit, and harmonic removal filter processing unit at the previous stage of the PLL processing unit, the possibility of demodulation can be set according to the train detection level. The relationship between the receiving level and the possibility of demodulation is shown in Fig. 4.

[0043] In such a constitution, only the amplification factor of the gain process is a value which can be set for each track circuit, so that the PLL processing unit can be designed in common and improvement of the productivity can be realized. An example of application to a plurality of track circuits is shown in Fig. 7.

[0044] To remove the harmonic component of an input signal generated in the limiter processing unit, it is requested to the harmonic filter processing unit to reduce the effect of harmonics of an odd degree which is mainly a component of square wave.

[0045] When the filter process is to be generally performed by the digital process, it is known that when a frequency which is 1/4 of the sampling frequency is set to a center frequency in the pass band, a necessary characteristic can be obtained by a lowest processing amount.

[0046] However, when the frequency becomes a half of the sampling frequency, an alias phenomenon is generated. Therefore, when the frequency which is 1/4 of the sampling frequency is set in the pass band as an input frequency, the same characteristic as that of the pass band at the frequency which is 1/4 of the sampling frequency also exists in the band around the frequency which is 3/4 of the sampling frequency. When a square wave is inputted for this filter characteristic, the frequency of harmonics of an odd degree doubly exists in the pass band at the frequency which is 1/4 of the sampling frequency and in the pass band generated at the frequency which is 3/4 of the sampling frequency, so that necessary attenuation cannot be obtained.

[0047] Therefore, it is necessary to set the input frequency in a band which does not coincide with 1/4 of the sampling frequency. However, for a filter in which a band having a large difference from 1/4 of the sampling frequency is set as a pass band, a more processing amount is generally necessary. This results in an increase of the processing amount of the digital circuit and an increase of cost, so that it is required to minimize the difference as much as possible.

[0048] Therefore, using that the square wave component generated by the limiter process is mainly harmonics of an odd degree, the value of input frequency is set to a multiple of one-to-an-odd-degree of the sampling frequency, and the pass band is set to a band smaller than one-to-an-odd-degree of the sampling frequency around the input frequency, and all the bands other than one-to-an-odd-degree of the sampling frequency around the input frequency are set to stopping bands so as to realize a filter process of efficiently removing harmonics.

[0049] For example, a case that the input frequency is set to 2 [kHz], and the band necessary for demodulation is ±300 [Hz] around the input frequency, and the pass band of the filter is set to a band of 2/7 of the sampling frequency will be considered. Fig. 5 shows the filter characteristic. In this example, the sampling frequency is 7 [kHz] and the center frequency of the pass band is 2 [kHz]. In this case, it is necessary to set the pass band width to a band width smaller than 1/7 of the sampling frequency. However, since the band necessary for demodulation is of a band width of ±300 [Hz] around the input frequency 2 [kHz], so that the band necessary of demodulation will not be damaged. In this case, the pass band is set to a band of ±300 [Hz] around 2 [kHz]. On the other hand, the stopping bands are all the bands other than 1/7 of the sampling frequency around the input frequency 2 [kHz], so that it is necessary to set all the bands other than the band width 1 [kHz] around 2 [kHz] to stopping bands. In this case, the frequency band lower than 1.5 [kHz] and the frequency band higher than 2.5 [kHz] are set to stopping bands.

[0050] On the other hand, since there exists a pass band by aliasing, at a frequency more than 3.5 [kHz] which is a half of the sampling frequency, the frequency characteristic at less than 3.5 [kHz] is reproduced in the loopback state. As a result, the same characteristic as that of the pass band also exists in the band more than 3.5 [kHz]. The characteristic of the pass band is such that the band less than ±300 [Hz] around 2.0 [kHz] which is a pass band is a band less than ±300 [Hz] around 5.0 [kHz] which loops back at 3.5 [kHz] which is a half of the sampling frequency. On the other hand, since the characteristic of stopping bands also loops back, the range from 3.5 [kHz] equivalent to 1/2 of the sampling frequency to 4.5 [kHz] and the range from 5.5 [kHz] to 7 [kHz] which is the sampling frequency are applicable bands.

[0051] On the other hand, the harmonic component mainly exists in a value of odd number times of the input frequency. In this case, since the input frequency is 2/7 of the sampling frequency, harmonics exist in the band odd number times of the band of 2/7 of the sampling frequency. The bands where the harmonics up to the 15th harmonics exist will be described hereunder.

[0052] The 1st harmonics have the same frequency as that of the input frequency and are the frequency component to be processed by the PLL process. Therefore, the 1st harmonics are equivalent to the pass band by this filter process. This frequency component exists in the range of ±300 [Hz] around 2 [kHz] which is the same as the input frequency and is equivalent to the band of 2/7 of the sampling frequency.

[0053] The 3rd harmonics exist in the range of ±300 [Hz] around 6 [kHz] which is 3 times of the input frequency 2 [kHz] and this is equivalent to that the 3rd harmonics exist in the range of ±300 [Hz] around 1 [kHz] when the sampling frequency is 7 [kHz].

[0054] Therefore, it is equivalent to the band of 1/7 of the sampling frequency.

[0055] The 5th harmonics exist in the range of ±300 [Hz] around 10 [kHz] which is 5 times of the input frequency 2 [kHz] and this is equivalent to that the 5th harmonics exist in the range of ±300 [Hz] around 3 [kHz] when the sampling frequency is 7 [kHz]. Therefore, it is equivalent to the band of 3/7 of the sampling frequency.

[0056] The 7th harmonics exist in the range of ±300 [Hz] around 14 [kHz] which is 7 times of the input frequency 2 [kHz] and this is equivalent to that the 7th harmonics exist in the range of ±300 [Hz] around 0 [kHz] when the sampling frequency is 7 [kHz]. Therefore, it is equivalent to the band of 0/7 of the sampling frequency.

[0057] The 9th harmonics exist in the range of ±300 [Hz] around 18 [kHz] which is 9 times of the input frequency 2 [kHz] and this is equivalent to that the 9th harmonics exist in the range of ±300 [Hz] around 3 [kHz] when the sampling frequency is 7 [kHz]. Therefore, it is equivalent to the band of 3/7 of the sampling frequency.

[0058] The 11th harmonics exist in the range of ±300 [Hz] around 22 [kHz] which is 11 times of the input frequency 2 [kHz] and this is equivalent to that the 11th harmonics exist in the range of ±300 [Hz] around 1 [kHz] when the sampling frequency is 7 [kHz]. Therefore, it is equivalent to the band of 1/7 of the sampling frequency.

[0059] The 13th harmonics exist in the range of ±300 [Hz] around 26 [kHz] which is 13 times of the input frequency 2 [kHz] and this is equivalent to that the 13th harmonics exist in the range of ±300 [Hz] around 2 [kHz] when the sampling frequency is 7 [kHz]. Therefore, it is equivalent to the band of 2/7 of the sampling frequency.

[0060] The 15th harmonics exist in the range of ±300 [Hz] around 30 [kHz] which is 15 times of the input frequency 2 [kHz] and this is equivalent to that the 15th harmonics exist in the range of ±300 [Hz] around 2 [kHz] when the sampling frequency is 7 [kHz]. Therefore, it is equivalent to the band of 2/7 of the sampling frequency.

[0061] Fig. 6 shows the relationship between harmonics and the filter characteristic. The harmonics of an odd degree coinciding with the pass band are the 13th and subsequent harmonics.

[0062] This effect is obtained from the Fourier conversion assuming an input signal as a perfect square wave. From the Fourier conversion, assuming the 1st harmonics as 0 [dB] in level, the level of the 13th harmonics for the 1st harmonics can be obtained as about -24 [dB]. For example, assuming that the attenuation of the pass band of the filter process is 0 [dB] and the output amplitude of the limiter is 1.0 max., the amplitude of the 1st harmonic component is 1.0, while the 13th harmonic component is less than 0.07 when it is converted to an amplitude. As a result, the output amplitude of the filter process is about 1.07 max. by the effect of the 13th harmonics and the harmonics can be effectively removed.

[0063] On the other hand, since the pass band exists at 2/7 of the sampling frequency, the difference of the pass band from 1/4 of the sampling frequency is small and the increase of the filter processing amount can be controlled smaller. By doing this, the harmonics can be effectively removed.

[0064] By use of the aforementioned constitution, the productivity of a train detector which is highly resistant to noise can be improved.

[0065] As another application example of this system, the equipment constitution when the system is applied to a water quality detector in a water bath is shown in Fig. 8. A pair of light emission device and light reception device is installed in the water bath, and the light emission device is connected to a transmitter, and the light reception device is connected to a receiver. The transmitter and receiver are connected to the water quality detector via a network.

[0066] With respect to the quality of water in the water bath, when the intensity of light generated by the light emission device is attenuated by the transmission factor of the quality of water and the intensity of light received by the light reception device is lower than a fixed value, the water quality detector displays a warning on the display unit and instructs improvement of the quality of water to the water quality control unit.

[0067] The threshold value of water quality detection varies with the installation distance between the light emission device and the light reception device. Therefore, it is necessary to individually set the threshold value for each combination of light emission device and light reception device.

[0068] In this case, by applying this system to the receivers and setting the threshold value of water quality detection as gain information of each receiver, it is obvious that the threshold value of water quality detection can be set to an optional value.

INDUSTRIAL UTILITY

[0069] As mentioned above, by use of the equipment constitution of the present invention, the productivity of a train detector which is highly resistant to noise can be improved.

Claims

1. A frequency modulated signal receiving method for executing the demodulation process of an inputted amplitude-dependent frequency modulated signal, wherein the gain process of setting the amplification factor of said inputted input signal so that the lower level of demodulation of said input signal coincides with the lower level of demodulation of said demodulation process is executed, and the limiter process of controlling a level higher than the standard value of said input signal of said demodulation process to lower than the standard value is executed, and the filter process of removing harmonics generated by said limiter process is executed, and said demodulation process is executed after said filter process.

2. A frequency modulated signal receiving method according to Claim 1, wherein the sampling frequency when said filter process is to be executed by the digital process is set to a multiple of one-to-an-odd-number of the sampling frequency for the frequency to be processed, and at the same time, the pass band width of said filter including the band width necessary for demodulation is set to a band smaller than one-to-an-odd-number of said sampling frequency around a multiple of one-to-an-odd-number of said sampling frequency, and all the bands other than said band of one-to-an-odd-number of said sampling frequency around said multiple of one-to-an-odd-number of said sampling frequency are set to stopping bands.

3. A frequency modulated signal receiver for executing the demodulation process of an inputted amplitude-dependent frequency modulated signal, comprising a gain processing unit of setting the amplification factor of said inputted input signal so that the lower level of demodulation of said input signal coincides with the lower level of demodulation of said demodulation process, a limiter processing unit of controlling a level higher than the standard value of said input signal of said demodulation process to lower than said standard value, a filter processing unit of removing harmonics generated as a result of processing by said limiter processing unit, and a demodulation processing unit for demodulating a signal processed by said filter processing unit.

Fig. 1

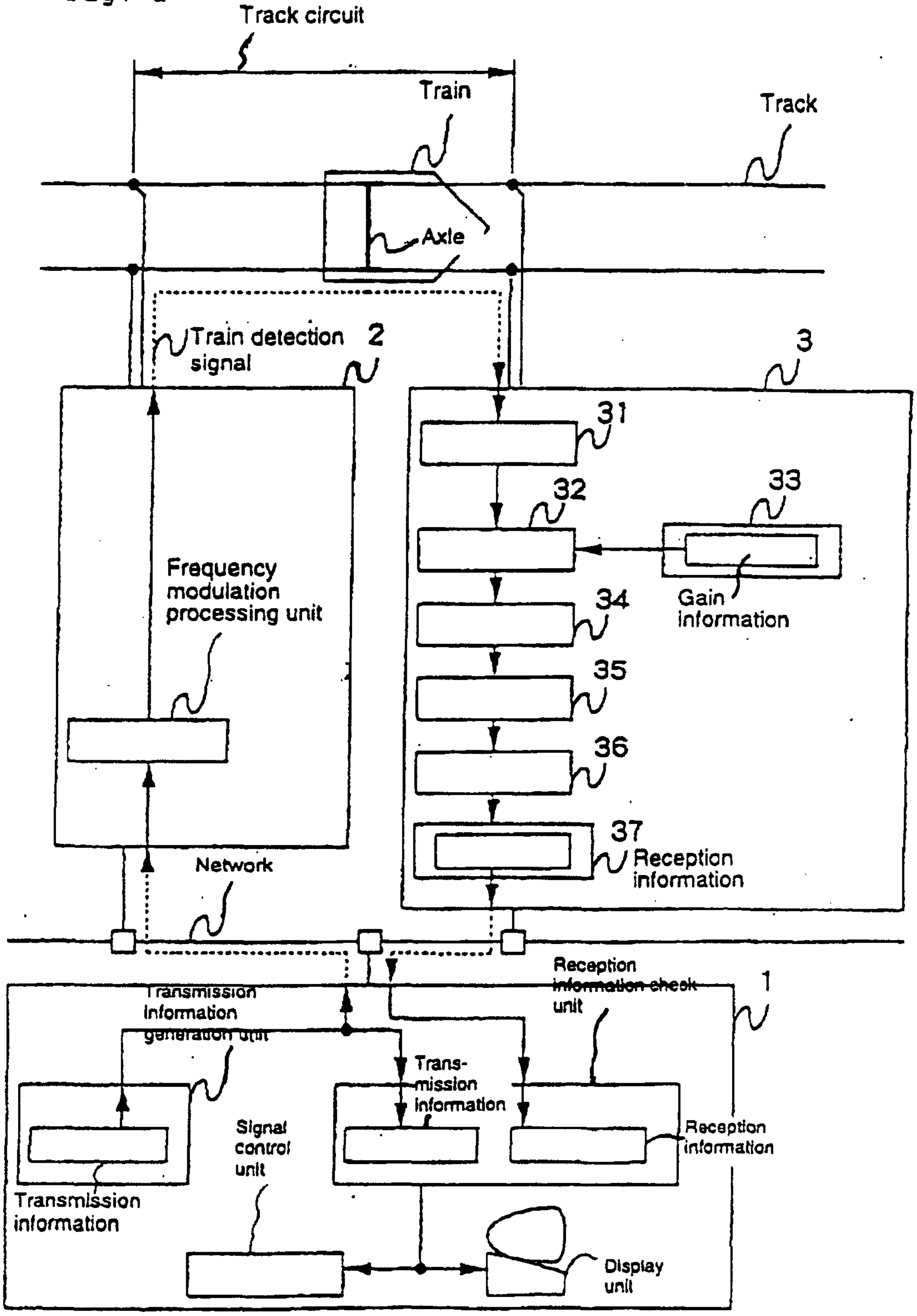

Track circuit
Train
Track
Axle
Train detection signal
2
3
31
32
33
Gain information
34
35
36
37
Reception information
Frequency modulation processing unit
Network
Transmission information generation unit
Reception information check unit
1
Trans-mission information
Reception information
Signal control unit
Transmission information
Display unit

Fig. 2

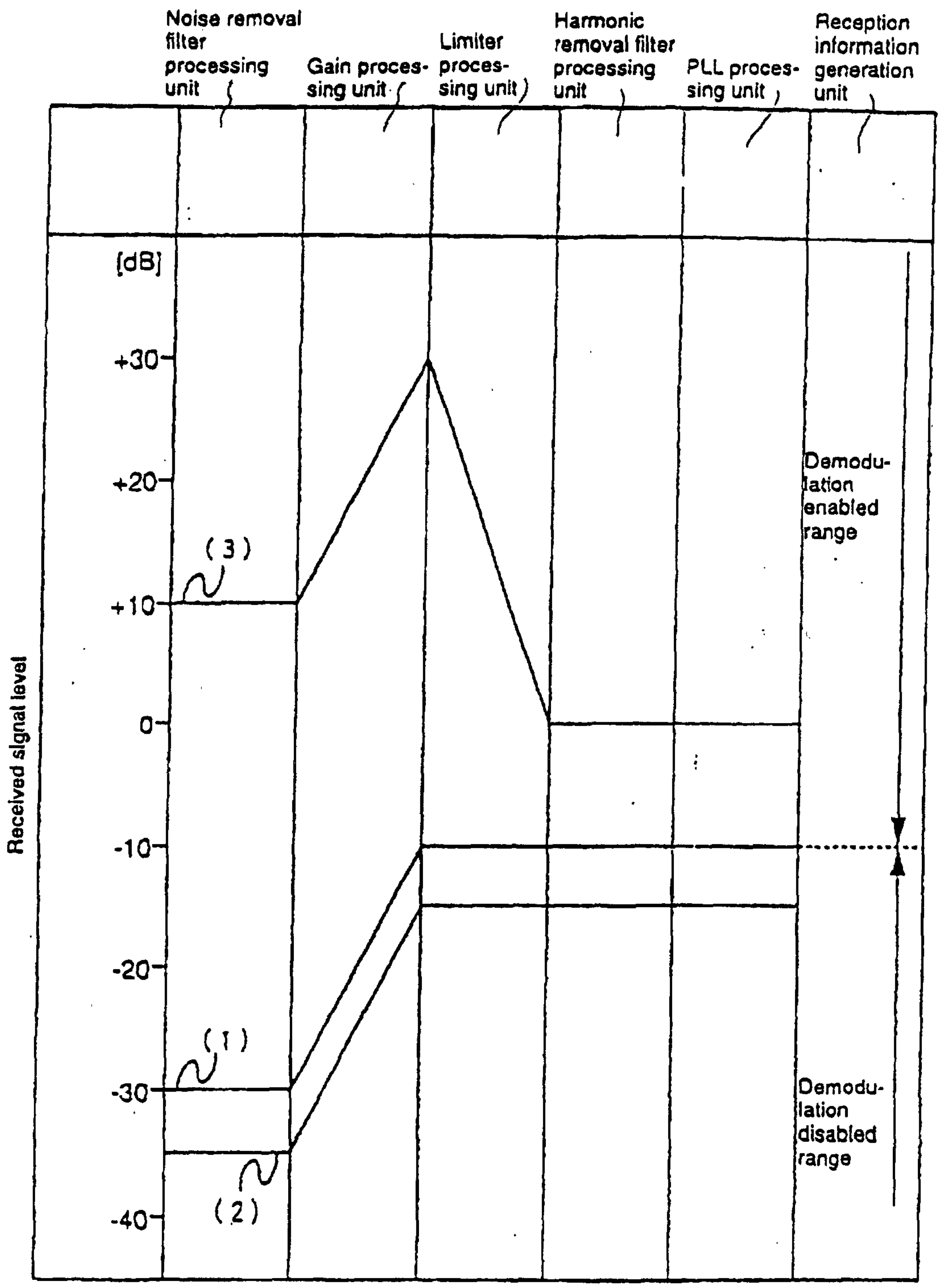

Noise removal filter processing unit
Gain processing unit
Limiter processing unit
Harmonic removal filter processing unit
PLL processing unit
Reception information generation unit
[dB]
+30
+20
+10
0
-10
-20
-30
-40
Received signal level
(3)
(1)
(2)
Demodulation enabled range
Demodulation disabled range

Fig. 3

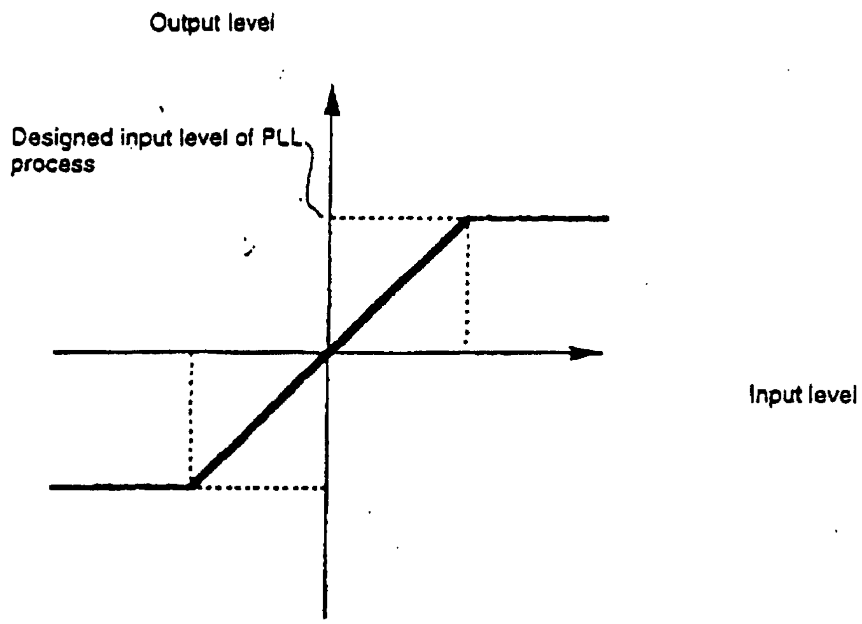

Output level
Designed input level of PLL process
Input level

Fig. 4

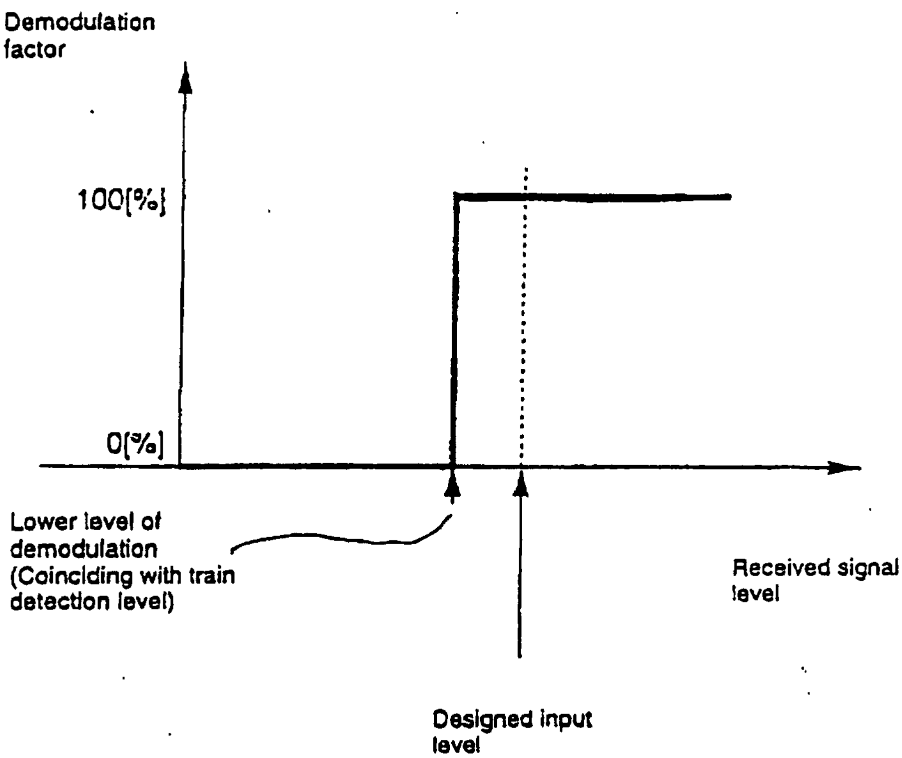
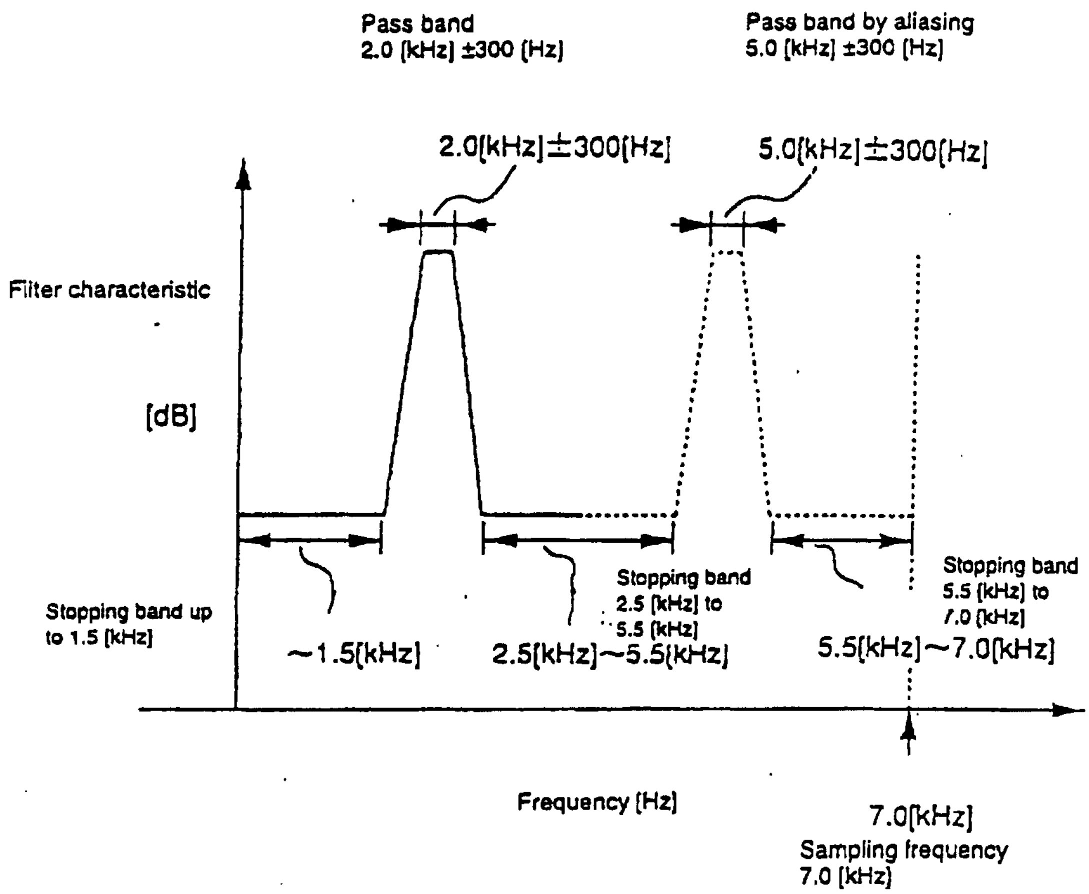

Demodulation factor
100[%]
0[%]
Lower level of demodulation (Coinciding with train detection level)
Received signal level
Designed input level

Fig. 5



Pass band
2.0 [kHz] ±300 [Hz]
Pass band by aliasing
5.0 [kHz] ±300 [Hz]
2.0[kHz]±300[Hz]
5.0[kHz]±300[Hz]
Filter characteristic
[dB]
Stopping band up to 1.5 [kHz]
~1.5[kHz]
Stopping band 2.5 [kHz] to 5.5 [kHz]
2.5[kHz]~5.5[kHz]
Stopping band 5.5 [kHz] to 7.0 [kHz]
5.5[kHz]~7.0[kHz]
Frequency [Hz]
7.0[kHz]
Sampling frequency 7.0 [kHz]

Fig. 6

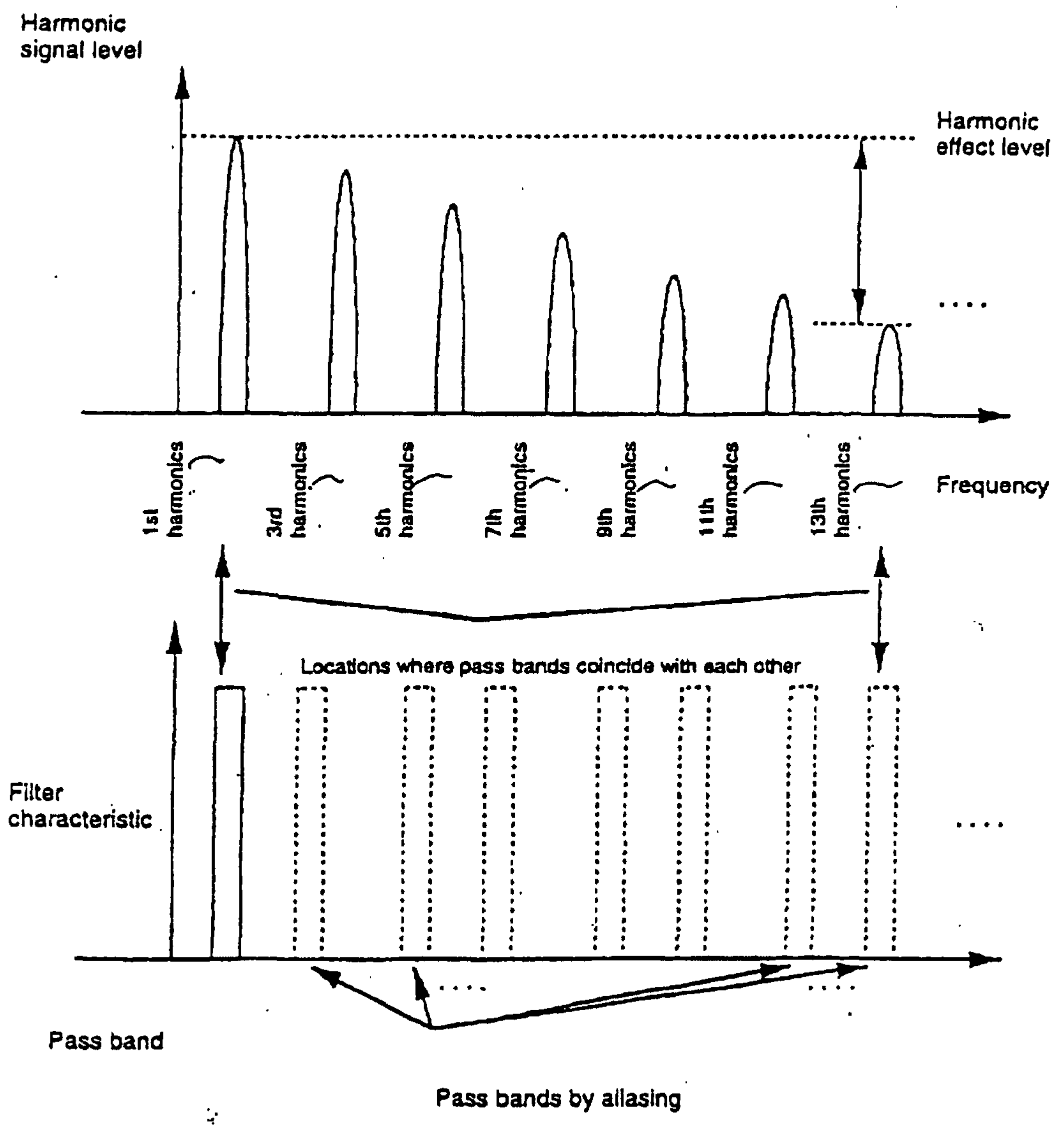

Harmonic
signal level
Harmonic
effect level
....
1st
harmonics
3rd
harmonics
5th
harmonics
7th
harmonics
9th
harmonics
11th
harmonics
13th
harmonics
Frequency
Locations where pass bands coincide with each other
Filter
characteristic
....
Pass band
Pass bands by aliasing

Fig. 7

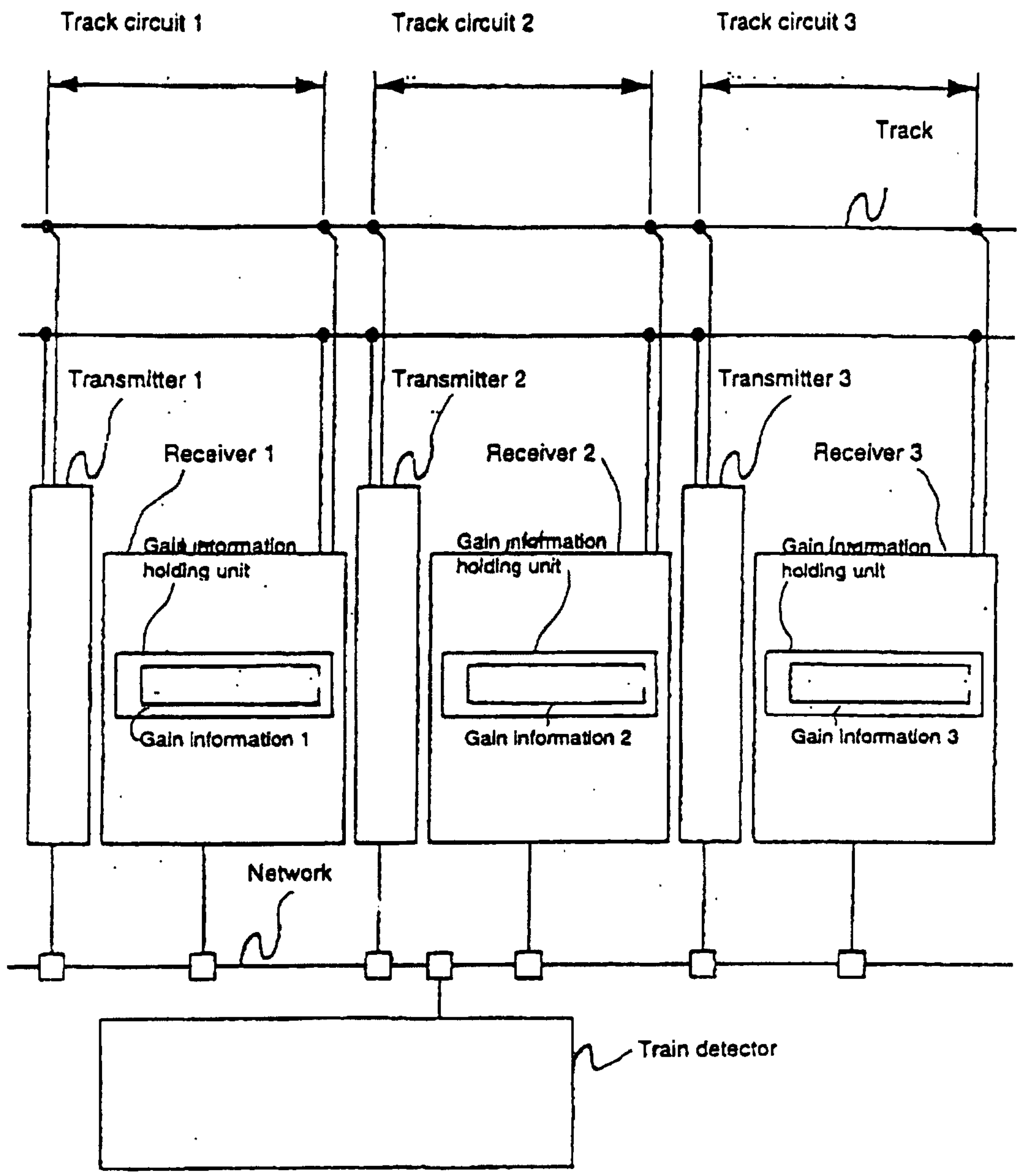
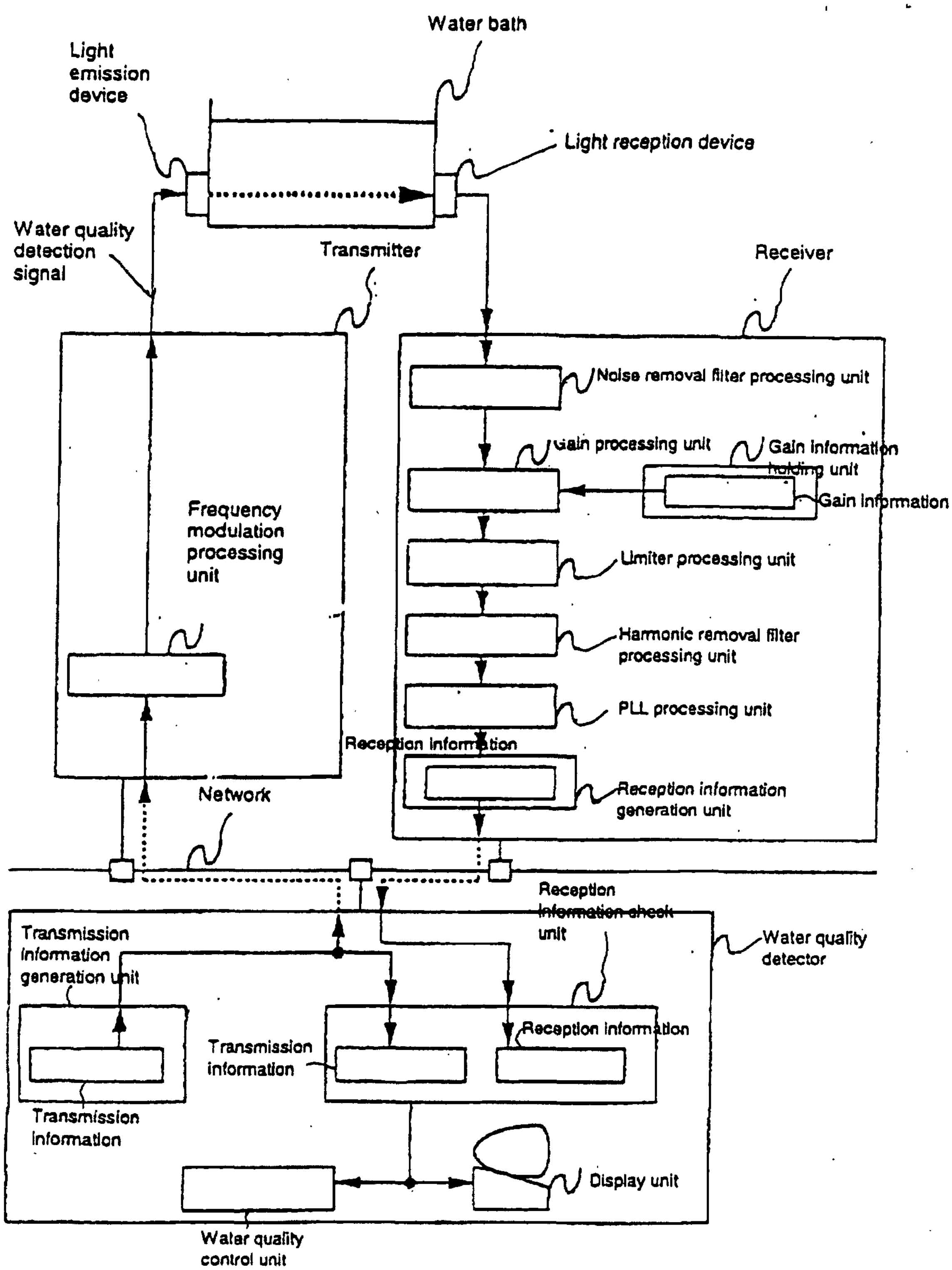

Track circuit 1
Track circuit 2
Track circuit 3
Track
Transmitter 1
Transmitter 2
Transmitter 3
Receiver 1
Receiver 2
Receiver 3
Gain information holding unit
Gain information holding unit
Gain information holding unit
Gain information 1
Gain information 2
Gain information 3
Network
Train detector

Fig. 8


Water bath
Light emission device
Light reception device
Water quality detection signal
Transmitter
Receiver
Noise removal filter processing unit
Gain processing unit
Gain information holding unit
Gain information
Frequency modulation processing unit
Limiter processing unit
Harmonic removal filter processing unit
PLL processing unit
Reception information
Reception information generation unit
Network
Reception information check unit
Water quality detector
Transmission information generation unit
Transmission information
Reception information
Transmission information
Display unit
Water quality control unit

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/04756

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl[6] H04B1/10, B61L1/18, G01N27/26

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[6] H04B1/10, B61L1/18, G01N27/26

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

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-1999
Kokai Jitsuyo Shinan Koho	1971-1999	Jitsuyo Shinan Toroku Koho	1996-1999

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	JP, 51-18122, B1 (VICTOR COMPANY OF JAPAN, LIMITED), 08 June, 1976 (08.06.76), Full text; Figs. 1 to 4 (Family: none)	1-3
Y	JP, 50-57763, A (Tokyo Shibaura Denki K.K.), 20 May, 1975 (20.05.75), page 2, upper left column, lines 4 to 16 (Family: none)	1-3
Y	JP, 54-124956, A (Kabushiki Kaisha Noboru Denki Seisakusho), 28 September, 1979 (28.09.79), page 2, upper right column, line 1 to lower left column, line 5; page 3, upper left column, lines 5-17; Figs. 1-6 (Family: none)	1-3
A	JP, 1-212001, A (Matsushita Electric Industrial Co., Ltd.), 25 August, 1989 (25.08.89), page 2, upper right column, lines 5-12; page 2, lower left column, line 18 to lower right column, line 8; page 4, upper left column, lines 9-19 (Family: none)	1-3

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

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"&" document member of the same patent family

Date of the actual completion of the international search 30 November, 1999 (30.11.99)	Date of mailing of the international search report 14 December, 1999 (14.12.99)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/04756

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 57-113381, A (THE NIPPON SIGNAL CO., LTD.), 14 July, 1982 (14.07.82), Full text; Figs. 1 to 5 (Family: none)	1-3
A	JP, 6-92232, A (Kyosan Electric MFG Co., Ltd.), 05 April, 1994 (05.04.94), Full text; Figs. 1 to 5 (Family: none)	1-3
A	JP, 60-138441, A (TOSHIBA CORPORATION), 23 July, 1985 (23.07.85), page 1, lower left column, line 20 to page 2, lower right column, line 5 (Family: none)	1-3

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