

RETRANSMITTING APPARATUS OF TERRESTRIAL DIGITAL BROADCASTING

TECHNICAL FIELD

5 [0001] The present invention relates to a retransmitting apparatus of terrestrial digital broadcasting, specifically to a retransmitting apparatus receiving a segment of a partially-received part of terrestrial digital television broadcasting or terrestrial digital sound broadcasting, and retransmitting the received signal.

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RELATED ART

[0002] The Japanese terrestrial digital television broadcasting adopts the OFDM (Orthogonal Frequency Division Multiplex) modulation system which is referred to as the ISDB-T (Integrated Services Digital Broadcasting-Terrestrial) system, and broadcasts data to be transmitted as 13 segments.

15 [0003] While a television provided at home collectively receives the 13 segments with a fixed antenna, only one segment which is a central one of the 13 segments is received, so-called, partially-received, in broadcasting for a portable/mobile device such as a mobile phone and a PDA (Personal Digital Assistant).

20 [0004] Here, it is necessary that the segment of broadcasting for the portable/mobile device can be well received also in a building shade out of doors, inside a building, in an underground shopping area, and the like, therefore, the retransmitting apparatus becomes necessary which retransmits the partially-received segment.

25 [0005] Conventionally, the following four methods are known as a retransmitting method of the terrestrial digital broadcasting. That is, the first retransmitting method is the method which retransmits with a single frequency network transmitting the same content signal by using the same frequency from a plurality of transmitting stations or relay stations when all of the 13 segments are retransmitted (for example, refer to Patent document 1: Japanese Patent Application Laid-Open No. 10-75262, Patent document 2: Japanese Patent Application Laid-Open No. 10-75263, Patent document 3: Japanese Patent

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Application Laid-Open No. 10-28105). The second retransmitting method is the method which retransmits with a two-frequency network converting a frequency of a signal received at a relay station to transmit with the frequency which is different from the frequency of the received signal when all of the 13 segments
5 are retransmitted (for example, refer to Non-Patent document 1: Aiichirou Tsuzuku, etc., "Digital Terrestrial Television broadcasting with OFDM : A Study of Double Frequency Network", 1995 Proceedings of the Institute of Electronics, Information and Communication Engineers (IEICE) General Conference, pp. 277 - 278).

10 [0006] The third retransmitting method is the method which extracts only the partially-received part with a filter, and retransmits only the partially-received part by constructing a network executing only the partially-receiving (for example, refer to Patent document 4: Japanese Patent Application Laid-Open No. 2005-341195). The fourth retransmitting method is the method which extracts
15 only the partially-received part with a filter, Fourier-transforms to process in a frequency area, and combines the plurality of segments to retransmit (for example, refer to Patent document 5: Japanese Patent Application Laid-Open No. 2006-109283).

[0008] The above first and second retransmitting methods retransmit data to
20 be transmitted of the whole of 13 segments by using a band width of six MHz per one channel in case of the terrestrial digital television broadcasting. However, even when such a retransmitting method retransmit for the portable/mobile device in a building shade out of doors, inside a building, in an underground shopping area, and the like, while it is enough to retransmit only one segment of
25 the partially-received part, it is necessary to retransmit the whole of signal band width which is six MHz of 13 segments per one channel. For example, when data of eight channels is retransmitted with two frequencies, it is necessary to secure the band width of 48 MHz (six MHz $\times$ eight channels) which corresponds to a channel width of eight channels. In such a case, there exists such a problem
30 that the current domestic transmission assignment frequencies are crowded, so that it is difficult to secure such a band width.

[0009] While the third retransmitting method extracts only the partially-received part to retransmit, a band width used for the retransmitting is six MHz

per one channel, so that there exists the same problem as that of the first and second retransmitting methods in that a bandwidth of 48 MHz is also necessary in case of eight channels. There exists also such a problem that the characteristic of the fixed receiving around a retransmitting point may be degraded.

5 [0010] While the fourth retransmitting method combines a plurality of segment to retransmits, it is necessary to process in a frequency area, so that Fourier transformation and reverse Fourier transformation are executed, and there exists such a problem that a delay time from receiving a signal to retransmitting the signal becomes larger, and a circuit scale also becomes larger.

10 [0011] The present invention has been invented to solve the above problems, and an object of the present invention is to provide such a retransmitting apparatus of the broadcasting for the portable/mobile device that the delay time is short and the downsizing can be realized without assigning a useless frequency in the retransmitting apparatus of the terrestrial digital broadcasting.

DISCLOSURE OF THE INVENTION

[0012] To solve the above problem, a retransmitting apparatus of the terrestrial digital broadcasting according to the present invention extracts only the partially-received part of a terrestrial digital broadcasting wave with a filter, and combine the partially-received parts of the plurality of terrestrial digital broadcasting waves to each of adjacent segments to retransmit as one terrestrial digital broadcasting wave only by digitally processing in a time area. Thereby, the retransmitting apparatus of the terrestrial digital broadcasting according to the present invention can retransmit with a small bandwidth without the Fourier transformation and the reverse Fourier transformation.

25 [0013] That is, a retransmitting apparatus of the terrestrial digital broadcasting according to the present invention receives a plurality of waves of the terrestrial digital broadcasting configured with a plurality of segments, extracts one segment from such terrestrial digital broadcasting waves respectively, and combines the extracted segments to retransmit as the terrestrial digital broadcasting wave, and comprises a plurality of tuning units, a plurality of digitally-processing units corresponding to each of the tuning units, an adding

unit, and a retransmitting unit, and the tuning unit includes a receiving-
converting means for selecting one broadcasting wave of a plurality of waves of
the received terrestrial digital broadcasting, and converting a RF band signal of
this broadcasting wave to an IF band signal, an AD converting means for
5 converting the IF signal converted by the receiving-converting means to a digital
IF signal, and an orthogonal demodulating means for orthogonal-demodulates the
digital IF signal converted by the AD converting means, and outputting an
equivalent base band signal, the digitally-processing unit includes a filtering
means for extracting one segment from the equivalent base band signal outputted
10 by the orthogonal demodulating means of the tuning unit, and a segment
allocating means for converting a frequency of the equivalent base band signal of
one segment extracted by the filtering means to a position for combining a
plurality of segments, the adding unit includes a means for adding and
synthesizing the equivalent base band signals of each one of segments whose
15 frequencies are converted by the segment allocating means of the plurality of
digitally-processing unit, and the retransmitting unit includes an orthogonal
modulating means for orthogonal-modulating the equivalent base band signal
added and synthesized by the adding unit, and outputting the digital IF signal, a
DA converting means for converting the digital IF signal outputted by the
20 orthogonal modulating means to an analog IF signal, and a transmission-
converting means for converting the analog IF signal converted by the DA
converting means to the RF band signal to be retransmitted as the terrestrial
digital broadcasting wave, and amplifying the converted signal.

[0014] As described above, according to the present invention, in the
25 retransmitting apparatus of the terrestrial digital broadcasting, such a
retransmitting apparatus can be realized that a useless frequency is not assigned,
a delay time is short, and the downsizing can be realized.

BRIEF DESCRIPTION OF THE DRAWINGS

30 [0015] Fig. 1 is a block diagram illustrating a configuration of a
retransmitting apparatus of terrestrial digital broadcasting according to an
exemplary embodiment of the present invention (embodiment 1);

Fig. 2 is a diagram illustrating a configuration and a number of a segment

of the ISDB-T system;

Fig. 3 is a diagram illustrating a configuration example of a receiving channel and a transmitting channel;

Fig. 4 is a block diagram illustrating a configuration of the retransmitting apparatus of the terrestrial digital broadcasting according to an exemplary embodiment of the present invention (embodiment 2);

Fig. 5 is a diagram describing the processing of a GI replacing circuit of Fig. 4;

Fig. 6 is a block diagram illustrating a configuration of the retransmitting apparatus of the terrestrial digital broadcasting according to an exemplary embodiment of the present invention (embodiment 3);

Fig. 7 is a block diagram illustrating a configuration of the retransmitting apparatus of the terrestrial digital broadcasting according to an exemplary embodiment of the present invention (embodiment 4);

Fig. 8 is a pattern diagram illustrating SP allocation;

Fig. 9 is a block diagram illustrating a configuration of the retransmitting apparatus of the terrestrial digital broadcasting according to an exemplary embodiment of the present invention (embodiment 5);

Fig. 10 is a block diagram illustrating a configuration of the retransmitting apparatus of the terrestrial digital broadcasting according to an exemplary embodiment of the present invention (embodiment 6);

Fig. 11 is a block diagram illustrating a configuration of the retransmitting apparatus of the terrestrial digital broadcasting according to an exemplary embodiment of the present invention (embodiment 7);

Fig. 12 is a block diagram illustrating a configuration of the retransmitting apparatus of the terrestrial digital broadcasting according to an exemplary embodiment of the present invention (embodiment 8);

Fig. 13 is a block diagram illustrating a configuration of the retransmitting apparatus of the terrestrial digital broadcasting according to an exemplary embodiment of the present invention (embodiment 9); and

Fig. 14 is a block diagram illustrating a configuration of the retransmitting apparatus of the terrestrial digital broadcasting according to an exemplary embodiment of the present invention (embodiment 10).

BEST MODE FOR CARRYING OUT THE INVENTION

[0016] The preferred embodiments of the present invention will be in detail described below by using the drawings. The embodiments of the present invention will be described as designating the retransmitting apparatus as an example, which receives and retransmits the terrestrial digital television broadcasting.

[0017] Fig. 2 is a diagram illustrating a configuration and a number of a segment of the ISDB-T system. In the ISDB-T system, 5600 or more subcarriers configuring an OFDM signal are divided to 13 groups, and each of the groups is referred to as a segment. The segment is identified with segment numbers of 0 to 12, the segment whose segment number is 0 is a segment of the partially-received part, and data for the portable/mobile device is assigned to the segment whose segment number is 0. Such 13 segments correspond to one channel, a band width of the channel is six MHz. One channel configured with the 13 segments, whose band width is six MHz, is assigned to a broadcaster, and each broadcaster broadcasts the OFDM signal of the ISDB-T system in such a channel.

[0018] Fig. 3 is a diagram illustrating such an example that each of one-segment parts of eight channels is combined as a configuration example of a receiving channel and a transmitting channel in the retransmitting apparatus of the terrestrial digital broadcasting. As illustrated in Fig. 3, it is assumed that any channel of eight channels (UHF13, 14, 15, 16, 17, 18, 19, and 20ch) is assigned to a plurality of broadcaster respectively. The retransmitting apparatus of the terrestrial digital broadcasting is an apparatus which receives the plurality of terrestrial digital broadcasting waves, extracts the partially-received part, whose segment number is 0, from each of the terrestrial digital broadcasting waves, combines each of the partially-received parts, and transmits the combined signal as a signal to be retransmitted with a unused RF signal, e.g. UHF53ch.

[0019] The retransmitting apparatus of the terrestrial digital broadcasting will be specifically described below by using embodiments 1 to 10. The retransmitting apparatus of the terrestrial digital broadcasting according to the embodiment 1 receives and processes terrestrial digital television broadcasting

for every channel system without a Fourier transformation, and combines each of the extracted partially-received parts to retransmit. The retransmitting apparatus of the terrestrial digital broadcasting according to the embodiment 2 receives and processes terrestrial digital television broadcasting without the Fourier transformation for each system as well as the embodiment 1, and replaces GI (Guard Interval) for each of the extracted partially-received parts to retransmit. The retransmitting apparatus of the terrestrial digital broadcasting according to the embodiment 3 conforms symbol timings for each of the extracted partially-received parts to retransmit. The retransmitting apparatus of the terrestrial digital broadcasting according to the embodiment 4 conforms symbol timings and SP (Scattered Pilot) patterns for each of the extracted partially-received parts to retransmit. The retransmitting apparatus of the terrestrial digital broadcasting according to the embodiment 5 conforms frame timings for each of the extracted partially-received parts to retransmit. The retransmitting apparatus of the terrestrial digital broadcasting according to the embodiments 6 to 10 adds a TS (Transport Stream) signal which is originally generated separately from the terrestrial digital television broadcasting to transmit along with the terrestrial digital television broadcasting, and uses the techniques of the embodiments 1 to 5 respectively.

20 [Embodiment 1]

[0020] First, the embodiment 1 will be described. Fig. 1 is a block diagram illustrating a configuration (embodiment 1) of the retransmitting apparatus of the terrestrial digital broadcasting according to the exemplary embodiment of the present invention. This retransmitting apparatus 1 comprises a receiving antenna unit 100, N tuning units 200 (200-1, 200-2, ..., 200-N), N digitally-processing units 311 (311-1, 311-2, ..., 311-N), an adding circuit 400, a retransmitting unit 500, and a transmitting antenna unit 600. Meanwhile, the tuning units 200 and the digitally-processing units 311 are configured with N systems, and each of the systems is configured with the same circuit, so that only one system will be described below. The tuning unit 200 includes a receiving-converting circuit 201, an AD converting circuit 202, and an orthogonal demodulating circuit 203, the digitally-processing unit 311 includes a LPF (Low Pass Filter) circuit 301 and a segment allocating circuit 302, and the

retransmitting unit 500 includes an orthogonal modulating circuit 501, a DA converting circuit 502, and a transmission-converting circuit 503. Meanwhile, N is equal to or less than 13 (hereinafter, this condition is the same).

[0021] The terrestrial digital broadcasting received by the receiving antenna unit 100 is distributed by a distributor (not illustrated) to the number of the terrestrial digital broadcasting waves (N waves). When the tuning unit 200 inputs the RF signal which is the distributed terrestrial digital broadcasting, the receiving-converting circuit 201 of the tuning unit 200 once converts the inputted RF signal to an intermediate frequency (for example, 57 MHz used for a household receiver), passes through a SAW (Surface Acoustic Wave) filter, and subsequently, converts the frequency again to a low frequency (for example, four MHz which is a half of FFT (Fast Fourier Transform) frequency). Thereby, only the channel is selected which is previously set for each system.

[0022] The AD converting circuit 202 inputs the signal whose frequency is converted by the receiving-converting circuit 201, and A/D-converts to a digital signal with a sampling frequency (for example, 16 MHz which is a double of the FFT frequency). The orthogonal demodulating circuit 203 inputs the digital signal A/D-converted by the AD converting circuit 202, and orthogonal-demodulates to convert to an equivalent base band signal.

[0023] The LPF circuit 301 of the digitally-processing unit 311 inputs the equivalent base band signal converted by the orthogonal demodulating circuit 203, and extracts only the one-segment part signal (partially-received part) by the filter-processing. The segment allocating circuit 302 inputs the one-segment part signal extracted by the LPF circuit 301, and converts a frequency to the segment which is allocated when the signal is combined to one equivalent base band signal.

[0024] The adding circuit 400 inputs the equivalent base band signals of the one-segments digitally-processed by the digitally-processing units 311 of N systems, and adds and synthesizes such equivalent base band signals.

[0025] The orthogonal modulating circuit 501 of the retransmitting unit 500 inputs the equivalent base band signal which is added and synthesized by the adding circuit 400, and orthogonal-modulates to convert. The DA converting circuit 502 inputs a digital signal converted by the orthogonal modulating circuit

501, and D/A-converts the inputted digital signal to generate a low frequency signal (e.g. four MHz) by using the same frequency (e.g. 16 MHz: four times of four MHz) as that of the AD converting circuit 202. The transmission-converting circuit 503 inputs the low frequency signal D/A-converted by the DA
5 converting circuit 502, once converts a frequency to an intermediate frequency (e.g. 37. 15 MHz: frequency of IF signal), subsequently, converts again a frequency to the RF signal for retransmitting, and amplifies to a desired transmitting electric power. As described above, the RF signal which is frequency-converted and amplified by the transmission-converting circuit 503 is
10 retransmitted through the transmitting antenna unit 600.

[0026] As described above, the retransmitting apparatus 1 of the terrestrial digital broadcasting according to the embodiment 1 extracts with a filter only the partially-received part which is a service broadcasting for the portable/mobile device of the terrestrial digital broadcasting, and without Fourier-transforming
15 and reverse-Fourier-transforming, and with only digitally-processing in a time area, combines the partially-received parts of the plurality of terrestrial digital broadcasting waves to each of adjacent segments to retransmit as one RF signal. Thereby, the retransmitting apparatus 1 can retransmit with a small band width (one channel = six MHz) without assigning a useless frequency for a receiving
20 apparatus in a building shade out of doors, inside a building, in an underground shopping area, and the like. Furthermore, it is not necessary to Fourier transform and reverse Fourier transform the data to be retransmitted of a main line system, and a circuit for such a Fourier transformation and a reverse Fourier transformation is not necessary, so that a delay time can be shortened, and the
25 easy downsizing can be realized.

[Embodiment 2]

[0027] Next, the embodiment 2 will be described. The embodiment 2 eliminates the error of a frequency factor, which is attributed to a jitter included in a local frequency when the receiving-converting circuit 201 converts a
30 frequency, prevents the interference among carriers in the adding circuit 400, and eliminates the signal distortion, which is generated by the filtering of the LPF circuit 301.

[0028] Fig. 4 is a block diagram illustrating a configuration (embodiment 2)

of the retransmitting apparatus of the terrestrial digital broadcasting according to the exemplary embodiment of the present invention. This retransmitting apparatus 2 comprises the receiving antenna unit 100 (not illustrated), the N tuning units 200, N digitally-processing units 312, the adder 400, the retransmitting unit 500, and the transmitting antenna unit 600 (not illustrated). Meanwhile, the digitally-processing units 312 are configured with N systems, and each of the systems is configured with the same circuit, so that only one system will be described below. The digitally-processing unit 312 includes a LPF circuit 301, a frequency error correcting circuit 303, a symbol synchronization detecting circuit 304, a GI replacing circuit 305, and a segment allocating circuit 302. As comparing the retransmitting apparatus 1 of the embodiment 1 illustrated in Fig. 1 with the retransmitting apparatus 2, while both apparatus are the same in that both apparatus are provided with the receiving antenna unit 100, the tuning unit 200, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600, both apparatus are different from each other in that the digitally-processing unit 312 of the retransmitting apparatus 2 is provided with the frequency error correcting circuit 303, the symbol synchronization detecting circuit 304, and the GI replacing circuit 305 in addition to the configuration of the digitally-processing unit 311 of the retransmitting apparatus 1. In Fig. 4, the same code as that of Fig. 1 is attached to the same component which is common to that of Fig. 1, and the detailed description will be omitted below.

[0029] When the digitally-processing unit 312 inputs the equivalent base band signal of the channel selected by the tuning unit 200, the LPF circuit 301 extracts only the one-segment part signal (partially-received part) with the filtering. The output of the LPF circuit 301 is distributed to two destinations, one is inputted to the frequency error correcting circuit 303, and the other is inputted to the symbol synchronization detecting circuit 304.

[0030] The symbol synchronization detecting circuit 304 inputs the one-segment part signal extracted by the LPF circuit 301, detects an amount of frequency error and the beginning part of symbols of the one-segment part signal, outputs the amount of frequency error to the frequency error correcting circuit 303, and outputs the beginning position information of symbols to the GI

replacing circuit 305.

[0031] Such an example that the symbol synchronization is detected will be illustrated below. Generally, the OFDM symbols are configured with a guard interval and an effective symbol interval, and a signal of the guard interval is cyclically duplicated from a part after the effective symbol. The symbol synchronization detecting circuit 304 obtains a guard correlation by utilizing this configuration, and detects the amount of frequency error and the beginning part of symbols. Specifically, for the inputted signal (a signal configured from the guard interval and the effective symbol interval), and a signal obtained by delaying the inputted signal by the effective symbol interval, a guard correlation of both signals is obtained by multiplying such signals to obtain a moving average of a guard interval width. Next, such a position that a value of the obtained guard correlation becomes a peak is detected as a symbol boundary (i.e. the beginning part of symbols). A correlation ($S_i i$) between I axis data of the inputted signal (equivalent base band signal) and I axis data delayed by the effective symbol interval, and a correlation ($S_i q$) between I axis data of the inputted signal and Q axis data delayed by the effective symbol interval are obtained respectively, and the amount of frequency error is detected based on such correlation values. Meanwhile, regarding the detailed description of a technique for detecting the beginning position of symbols and the amount of frequency error, refer to "Takashi Seki, etc. [A New Frequency Synchronizing Technique for OFDM Demodulators Using Guard Intervals], the Institute of Television Engineers of Japan (ITEJ) technical report, 1995 August 24".

[0032] The frequency error correcting circuit 303 inputs the one-segment part signal from the LPF circuit 301, inputs the amount of frequency error from the symbol synchronization detecting circuit 304, and corrects the frequency error of the inputted signal of the one-segment part by using the inputted amount of frequency error. In the receiving-converting circuit 201, since a jitter is included in a local frequency used when a frequency is converted, errors are induced in the frequency factor, and the adding circuit 400 may induce the interference among carriers when the one-segment part signal of each channel is synthesized. The frequency error correcting circuit 303 can prevent the interference among carriers attributed to the frequency factor errors in the case of

the frequency conversion.

[0033] The GI replacing circuit 305 inputs the corrected signal of the one-segment part from the frequency error correcting circuit 303, inputs symbol beginning position information from the symbol synchronization detecting circuit 304, extracts a signal of one symbol length based on the inputted symbol beginning position information for the inputted signal of the one-segment part to replace GI.

[0034] Fig. 5 is a diagram describing the processing of the GI replacing circuit 305. The GI replacing circuit 305 eliminates the distortion of the beginning part of a signal of one symbol length for the inputted signal of the one-segment part with the following processing by utilizing such a fact that a signal of the guard interval of the OFDM symbols configured with the guard interval and the effective symbol interval is duplicated to a rear part of the effective symbol. First, the GI replacing circuit 305 specifies a symbol beginning position based on the inputted symbol beginning position information (1), and extracts a signal of the effective symbol length from a starting point located apart by $GI/2$ from the symbol beginning position (2). Then, the GI replacing circuit 305 moves a signal between the beginning position and a position of $GI/2$ length of the extracted signal of the effective symbol length to a rear part to re-align (3), and adds a rear part of the re-aligned signal to the beginning part as GI depending on the pre-set GI ratio (4). Thereby, a new signal of one symbol length is obtained. In the LPF circuit 301, the distortion may be induced by the filtering at the beginning and the rear parts of one symbol length. The GI replacing circuit 305 can eliminate the signal distortion attributed to the filtering.

[0035] Returning to Fig. 4, the segment allocating circuit 302 inputs the one-segment part signal whose GI is replaced by the GI replacing circuit 305, and converts a frequency to the segment allocated when the signal is combined to one equivalent base band signal.

[0036] As described above, the retransmitting apparatus 2 of the terrestrial digital broadcasting according to the embodiment 2 can obtain the same advantageous effect as that of the embodiment 1. The frequency error correcting circuit 303 can eliminate the error of a frequency factor attributed to a jitter included in the local frequency when the receiving-converting circuit 201

converts a frequency, and can prevent the interference among carriers in the adding circuit 400. The GI replacing circuit 305 can eliminate the distortion of the beginning and rear parts of a signal of one symbol length, which is induced by the filtering of the LPF circuit 301. As a result, in a receiving apparatus
5 receiving the retransmitted signal from the retransmitting apparatus 2, the accuracy of the symbol synchronization is improved, the amount of frequency error correction becomes accurate, and the degradation in the retransmitting apparatus 2 can be reduced.

[Embodiment 3]

10 [0037] Next, the embodiment 3 will be described. The embodiment 3 eliminates the error of a frequency factor, which is attributed to a jitter included in a local frequency when the receiving-converting circuit 201 converts a frequency, prevents the interference among carriers at the adding circuit 400, and also synchronizes a symbol timing for the one-segment part signal of each system
15 to retransmit.

[0038] Fig. 6 is a block diagram illustrating a configuration (embodiment 3) of the retransmitting apparatus of the terrestrial digital broadcasting according to the exemplary embodiment of the present invention. This retransmitting apparatus 3 comprises the receiving antenna unit 100 (not illustrated), the N
20 tuning units 200, N digitally-processing units 313, a delay time adjusting circuit 307-3, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600 (not illustrated). The digitally-processing units 313 are configured with N systems, and each of the systems is configured with the same circuit, so that only one system will be described below. The digitally-
25 processing unit 313 includes a LPF circuit 301, a frequency error correcting circuit 303, a symbol synchronization detecting circuit 304, a digitally-delaying circuit 306, and a segment allocating circuit 302. As comparing the retransmitting apparatus 2 of the embodiment 2 illustrated in Fig. 4 with the retransmitting apparatus 3, while both apparatuses are the same in that both
30 apparatuses are provided with the receiving antenna unit 100, the tuning unit 200, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600, both apparatuses are different from each other in that a configuration of the digitally-processing unit 313 of the retransmitting apparatus 3 is different

from that of the digitally-processing unit 312 of the retransmitting apparatus 2, and the retransmitting apparatus 3 is further provided with the delay time adjusting circuit 307-3. In Fig. 6, the same code as that of Fig. 4 is attached to the component which is common to that of Fig. 4, and the detailed description will be omitted below.

5 [0039] The symbol synchronization detecting circuit 304 inputs the one-segment part signal extracted by the LPF circuit 301, detects the amount of frequency error and the beginning position of symbols of the one-segment part signal with a guard correlation, outputs the amount of frequency error to the frequency error correcting circuit 303, and outputs the beginning position
10 information of symbols to the delay time adjusting circuit 307-3.

[0040] The delay time adjusting circuit 307-3 inputs the beginning position information from the symbol synchronization detecting circuits 304 of the digitally-processing units 313-1 to N of each system respectively, and calculates
15 a delay time of each system based on a receiving timing of any one of the equivalent base band signals so that the symbol beginning timings of the equivalent base band signals of each system correspond to each other.

[0041] The digitally-delaying circuit 306 of each system inputs the one-segment part signal whose frequency error is corrected by the frequency error
20 correcting circuit 303, inputs a delay time calculated by the delay time adjusting circuit 307-3, and delays the signal whose frequency error is corrected by the delay time. The tuning by the tuning unit 200 and the digitally-processing by the digitally-processing unit 313 are executed for each system, so that a shift may be induced in the symbol timing of each system. The symbol timings of the
25 one-segment part signals of each system can be synchronized by the digitally-delaying circuit 306 and the delay time adjusting circuit 307-3.

[0042] The segment allocating circuit 302 inputs the one-segment part signal, which is delayed by the digitally-delaying circuit 306, and converts a frequency to the segment which is allocated when the signal is combined to one equivalent
30 base band signal.

[0043] As described above, the retransmitting apparatus 3 of the terrestrial digital broadcasting according to the embodiment 3 can obtain the same advantageous effect as that of the embodiment 1. The frequency error

correcting circuit 303 can eliminate the error of a frequency factor attributed to a jitter included in a local frequency when the receiving-converting circuit 201 converts a frequency, and prevent the interference among carriers in the adding circuit 400.

5 [0044] The symbol timings of the one-segment part signals of the each system can be synchronized by the digitally-delaying circuit 306 and the delay time adjusting circuit 307-3. Thereby, the symbol beginning positions of each of the equivalent base band signals can be conformed, so that when the signals are combined by the adding circuit 400 as one equivalent base band signal, the
10 signals can be retransmitted as synchronizing the symbol synchronization timings of all the 13 segments. As a result, in a receiving apparatus receiving a signal retransmitted from the retransmitting apparatus 3, the accuracy of the symbol synchronization is improved, and the amount of frequency error correction becomes correct.

15 [Embodiment 4]

[0045] Next, the embodiment 4 will be described. The embodiment 4 eliminates the error of a frequency factor, which is attributed to a jitter included in a local frequency when the receiving-converting circuit 201 converts a frequency, prevents the interference among carriers at the adding circuit 400, and
20 also synchronizes the symbol timing to retransmit so that the symbol beginning positions and SP patterns of the one-segment part signals of each system correspond to each other.

[0046] Fig. 7 is a block diagram illustrating a configuration (embodiment 4) of the retransmitting apparatus of the terrestrial digital broadcasting according to the exemplary embodiment of the present invention. This retransmitting
25 apparatus 4 comprises the receiving antenna unit 100 (not illustrated), the N tuning units 200, N digitally-processing units 314, a delay time adjusting circuit 307-4, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600 (not illustrated). The digitally-processing units 314 are
30 configured with N systems, and each of the systems is configured with the same circuit, so that only one system will be described below. The digitally-processing unit 314 includes the LPF circuit 301, the frequency error correcting circuit 303, the symbol synchronization detecting circuit 304, a FFT circuit 308,

an SP pattern detecting circuit 309, the digitally-delaying circuit 306, and the segment allocating circuit 302. As comparing the retransmitting apparatus 3 of the embodiment 3 illustrated in Fig. 6 with the retransmitting apparatus 4, while both apparatuses are the same in that both apparatuses are provided with the
5 receiving antenna unit 100, the tuning unit 200, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600, both apparatuses are different from each other in that the digitally-processing unit 314 of the retransmitting apparatus 4 is provided with the FFT circuit 308, the SP pattern detecting circuit 309, and the delay time adjusting circuit 307-4 which is
10 different from delay time adjusting circuit 307-3 of the retransmitting apparatus 3 in addition to the configuration of the digitally-processing unit 313 of the retransmitting apparatus 3. In Fig. 7, the same code as that of Fig. 6 is attached to the component which is common to that of Fig. 6, and the detailed description will be omitted below.

15 [0047] The symbol synchronization detecting circuit 304 inputs the one-segment part signal extracted from the LPF circuit 301, detects the amount of frequency error and the beginning position of symbols of the one-segment part signal with a guard correlation, outputs the amount of frequency error to the frequency error correcting circuit 303, and outputs the beginning position
20 information of symbols to the delay time adjusting circuit 307-4. The symbol synchronization detecting circuit 304 generates a timing signal indicating the beginning of an effective symbol interval for the one-segment part signal to output the timing signal to the FFT circuit 308.

[0048] The frequency error correcting circuit 303 inputs the one-segment
25 part signal from the LPF circuit 301, inputs the amount of frequency error from the symbol synchronization detecting circuit 304, corrects a frequency error of the one-segment part signal by using the amount of frequency error, and outputs the one-segment part signal, whose frequency error is corrected, to the digitally-delaying circuit 306 and the FFT circuit 308.

30 [0049] The FFT circuit 308 inputs the one-segment part signal, whose frequency error is corrected, from the frequency error correcting circuit 303, inputs the timing signal of an effective symbol from the symbol synchronization detecting circuit 304, and converts a signal of the effective symbol of the one-

segment part of a time area to a signal of a frequency area with the Fourier transformation.

[0050] The SP pattern detecting circuit 309 inputs the one-segment part signal of a frequency area from the FFT circuit 308, and detects what pattern the
5 inputted signal is in the SP allocation patterns (four patterns in total) of the ISDB-T system.

[0051] Fig. 8 is a pattern diagram illustrating an SP alignment. As illustrated in Fig. 8, the SP patterns of the ISDB-T system are configured with four patterns of SP patterns 1 to 4. The SP pattern detecting circuit 309 detects
10 any pattern of four SP patterns 1 to 4 for the inputted signal of one-segment part of a frequency area.

[0052] The delay time adjusting circuit 307-4 inputs the beginning position information of symbols from the symbol synchronization detecting circuits 304 of the digitally-processing units 314-1 to N of each system respectively, inputs
15 the SP pattern information from the SP pattern detecting circuits 309 respectively, and calculates a delay time of each system based on a receiving timing of any one of the equivalent base band signals so that the symbol beginning positions and the SP patterns of all the equivalent base band signals correspond to each other.

20 [0053] The digitally-delaying circuit 306 of each system inputs the one-segment part signal, whose frequency error is corrected by the frequency error correcting circuit 303, inputs a delay time calculated by the delay time adjusting circuit 307-4, and delays the signal whose frequency error is corrected by the delay time. The tuning by the tuning unit 200 and the digitally-processing by
25 the digitally-processing unit 314 are executed for each system, so that a shift may be induced for the symbol timing of each system. The symbol timings of the one-segment part signals of each system can be synchronized by the digitally-delaying circuit 306 and the delay time adjusting circuit 307-4 so that the beginning positions and the SP patterns of symbols correspond to each other.

30 [0054] The segment allocating circuit 302 inputs the one-segment part signal, whose is delayed by the digitally-delaying circuit 306, and converts a frequency to a segment allocated when the signal is combined to one equivalent base band signal.

[0055] As described above, the retransmitting apparatus 4 of the terrestrial digital broadcasting according to the embodiment 4 can obtain the same advantageous effect as that of the embodiment 1. The frequency error correcting circuit 303 can eliminate the error of a frequency factor, which is attributed to a jitter included in a local frequency when the receiving-converting circuit 201 converts a frequency, and prevent the interference among carriers in the adding circuit 400.

[0056] The symbol timings and the SP patterns of the one-segment part signals of each system can be conformed by the digitally-delaying circuit 306 and the delay time adjusting circuit 307-4. Thereby, when the signals are combined as one equivalent base band signal by the adding circuit 400, the signals can be retransmitted as conforming the symbol synchronization timings and also the SP patterns of all the 13 segments. As a result, in a receiving apparatus receiving a signal retransmitted from the retransmitting apparatus 4, the accuracy of the symbol synchronization is improved, the amount of frequency error correction becomes correct, and the SP of an adjacent segment can be used when the equalizing is executed.

[Embodiment 5]

[0057] Next, the embodiment 5 will be described. The embodiment 5 eliminates the error of a frequency factor, which is attributed to a jitter included in a local frequency when the receiving-converting circuit 201 converts a frequency, prevents the interference among carriers at the adding circuit 400, and also conforms the beginning positions of a frame for the one-segment part signals of each system to retransmit.

[0058] Fig. 9 is a block diagram illustrating a configuration (embodiment 5) of the retransmitting apparatus of the terrestrial digital broadcasting according to the exemplary embodiment of the present invention. This retransmitting apparatus 5 comprises the receiving antenna unit 100 (not illustrated), the N tuning units 200, N digitally-processing units 315, a delay time adjusting circuit 307-5, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600 (not illustrated). The digitally-processing units 315 are configured with N systems, and each of the systems is configured with the same circuit, so that only one system will be described below. The digitally-

processing unit 315 includes the LPF circuit 301, the frequency error correcting circuit 303, the symbol synchronization detecting circuit 304, the FFT circuit 308, a frame synchronization detecting circuit 310, the digitally-delaying circuit 306, and the segment allocating circuit 302. As comparing the retransmitting apparatus 4 of the embodiment 4 illustrated in Fig. 7 with the retransmitting apparatus 5, while both apparatuses are the same in that both apparatuses are provided with the receiving antenna unit 100, the tuning unit 200, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600, both apparatuses are different from each other in that the digitally-processing unit 315 of the retransmitting apparatus 5 is provided with the frame synchronization detecting circuit 310 instead of the SP pattern detecting circuit 309 of the digitally-processing unit 314 of the retransmitting apparatus 4, and the retransmitting apparatus 5 is provided with the delay time adjusting circuit 307-5 whose configuration is different from that of the delay time adjusting circuit 307-4 of the retransmitting apparatus 4. In Fig. 9, the same code as that of Fig. 7 is attached to the component which is common to that of Fig. 7, and the detailed description will be omitted below.

[0059] The frame synchronization detecting circuit 310 inputs the one-segment part signal of a frequency area from the FFT circuit 308, detects a frame beginning position from the TMCC (Transmission and Multiplexing Configuration Control) signal, and demodulates the signal. Next, the frame synchronization detecting circuit 310 outputs the detected frame beginning position information to the delay time adjusting circuit 307-5. Here, the frame information is attached to the TMCC signal of the ISDB-T system, so that the frame beginning position can be detected by monitoring the TMCC signal.

[0060] The delay time adjusting circuit 307-5 inputs the symbol beginning position information from the symbol synchronization detecting circuits 304 of the digitally-processing units 315-1 to N of each system respectively, inputs the frame beginning position information from the frame synchronization detecting circuits 310, and calculates a delay time of each system based on a receiving timing of any one of the equivalent base band signals so that the symbol beginning positions and the frame beginning positions of all the equivalent base band signals correspond to each other.

[0061] The digitally-delaying circuit 306 of each system inputs the one-segment part signal, whose frequency error is corrected by the frequency error correcting circuit 303, inputs a delay time calculated by the delay time adjusting circuit 307-5, and delays the signal whose frequency error is corrected by the delay time. The tuning by the tuning unit 200 and the digitally-processing by the digitally-processing unit 315 are executed for each system, so that a shift may be induced for the frame timing of each system. The symbol timings of the one-segment part signals of each system can be synchronized by the digitally-delaying circuit 306 and the delay time adjusting circuit 307-5 so that the frame beginning positions correspond to each other. In such a case, if the frame beginning positions correspond to each other, the symbol beginning positions and the SP patterns also correspond to each other.

[0062] The segment allocating circuit 302 inputs the one-segment part signal, whose is delayed by the digitally-delaying circuit 306, and converts a frequency to a segment allocated when the signal is combined to one equivalent base band signal.

[0063] As described above, the retransmitting apparatus 5 of the terrestrial digital broadcasting according to the embodiment 5 can obtain the same advantageous effect as that of the embodiment 1. The frequency error correcting circuit 303 can eliminate the error of a frequency factor, which is attributed to a jitter included in a local frequency when the receiving-converting circuit 201 converts a frequency, and prevent the interference among carriers in the adding circuit 400.

[0064] The frame beginning positions of the one-segment part signals of each system can be conformed by the digitally-delaying circuit 306 and the delay time adjusting circuit 307-5. Thereby, when the signals are combined as one equivalent base band signal by the adding circuit 400, the signals can be retransmitted as conforming the frame synchronization timings, and also, the symbol synchronization timings and the SP patterns of all the 13 segments. As a result, in a receiving apparatus receiving a signal retransmitted from the retransmitting apparatus 5, the accuracy of the symbol synchronization is improved, the amount of frequency error correction becomes correct, and the SP of an adjacent segment can be used when the equalizing is executed.

[Embodiment 6]

[0065] Next, the embodiment 6 will be described. The embodiment 6 adds the TS signal which is originally generated separately from the terrestrial digital television broadcasting, and transmits along with the terrestrial digital television broadcasting by using a technique of the embodiment 1. That is, the embodiment 6 combines N partially-received part signals of the terrestrial digital broadcasting of the received N waves and M original TS signals in one channel (band width: 6 MHz) to transmit. Meanwhile, $N + M$ is equal to or less than 13 (hereinafter, this condition is the same).

10 [0066] . Fig. 10 is a block diagram illustrating a configuration (embodiment 6) of the retransmitting apparatus of the terrestrial digital broadcasting according to the exemplary embodiment of the present invention. This retransmitting apparatus 6 comprises the receiving antenna unit 100, the N tuning units 200, N digitally-processing units 311, M modulating units 721, the adding circuit 400, 15 the retransmitting unit 500, and the transmitting antenna unit 600. The modulating units 721 are configured with M systems, and each of the systems is configured with the same circuit, so that only one system will be described. The modulating unit 721 includes an OFDM modulating circuit 701, an OFDM framing circuit 702, a reverse Fourier transforming circuit 703, a GI adding 20 circuit 704, and a segment allocating circuit 705. As comparing the retransmitting apparatus 1 of the embodiment 1 illustrated in Fig. 1 with the retransmitting apparatus 6, while both apparatuses are the same in that both apparatuses are provided with the receiving antenna unit 100, the tuning unit 200, the digitally-processing unit 311, the adding circuit 400, the retransmitting unit 25 500, and the transmitting antenna unit 600, both apparatuses are different from each other in that the retransmitting apparatus 6 is provided with the M modulating units 721 in addition to the configuration of the retransmitting apparatus 1. In Fig. 10, the same code as that of Fig. 1 is attached to the component which is common to that of Fig. 1, and the detailed description will 30 be omitted below.

[0067] When the original TS (for example, MPEG (Moving Picture Experts Group) - TS) signal such as a local broadcasting, a community broadcasting, a commercial, and a self-production is inputted, the OFDM modulating circuit 701

of the modulating unit 721 adds an error correcting code to the inputted original TS signal, executes a carrier modulation selected for a rate and an object, such as the QPSK (Quadrature Phase Shift Keying) modulation, the 16 QAM (Quadrature Amplitude Modulation) modulation, the 64 QAM modulation, and
5 executes a variety of interleavings.

[0068] The OFDM framing circuit 702 inputs a signal modulated by the OFDM modulating circuit 701, and adds a pilot carrier, an AC (Auxiliary Channel) and a TMCC to the same allocation as that of the partially-received part of the terrestrial digital broadcasting to execute the OFDM-framing.

10 [0069] The reverse Fourier-transforming circuit 703 inputs the signal which is OFDM-framed by the OFDM framing circuit 702, and reverse Fourier-transforms a carrier data of one symbol of the signal to a signal of a time area. The GI adding circuit 704 inputs the signal of a time area, which is reverse Fourier-transformed by the reverse Fourier-transforming circuit 703, and adds the
15 GI depending on a GI ratio which is previously set. The segment allocating circuit 705 inputs the signal to which the GI is added by the GI adding circuit 704, and converts a frequency to a segment allocated when the signal is combined to one equivalent base band signal. The segment allocating circuit 705 is functionally the same as the segment allocating circuit 302.

20 [0070] The adding circuit 400 inputs the equivalent base band signals of the one-segment part, which are digital-processed by the digitally-processing units 311 of N systems, inputs the equivalent base band signals of the original TS signals modulated by the modulating units 721 of M systems, and adds and synthesizes such equivalent base band signals.

25 [0071] As described above, the retransmitting apparatus 6 of the terrestrial digital broadcasting according to the embodiment 6 can obtain the same advantageous effect as that of the embodiment 1, add the TS signal which is originally generated separately from the terrestrial digital television broadcasting, and transmit along with the terrestrial digital television broadcasting.

30 [Embodiment 7]

[0072] Next, the embodiment 7 will be described. By using a technique of the embodiment 2, the embodiment 7 combines N partially-received part signals of the terrestrial digital broadcasting of N received waves and M original TS

signal in one channel to transmit.

[0073] Fig. 11 is a block diagram illustrating a configuration (embodiment 7) of the retransmitting apparatus of the terrestrial digital broadcasting according to the exemplary embodiment of the present invention. This retransmitting
5 apparatus 7 comprises the receiving antenna unit 100, the N tuning units 200, the N digitally-processing units 312, the M modulating units 721, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600. As comparing the retransmitting apparatus 2 of the embodiment 2 illustrated in Fig. 4 with the retransmitting apparatus 7, both apparatuses are different from each
10 other in that the retransmitting apparatus 7 is further provided with the modulating units 721 in addition to the configuration of the retransmitting apparatus 2. As comparing the retransmitting apparatus 6 of the embodiment 6 illustrated in Fig. 10 with the retransmitting apparatus 7, both apparatuses are different from each other in that the retransmitting apparatus 7 is provided with
15 the digitally-processing unit 312 whose configuration is different from that of the digitally-processing unit 311 of the embodiment 6.

[0074] The receiving antenna unit 100, the tuning unit 200, the digitally-processing unit 312, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600 are the same as those of the retransmitting
20 apparatus 2 of the embodiment 2, so that the description will be omitted. The modulating unit 721 is the same as that of the retransmitting apparatus 6 of the embodiment 6, so that the description will be omitted.

[0075] As described above, the retransmitting apparatus 7 of the terrestrial digital broadcasting according to the embodiment 7 can obtain the same
25 advantageous effect as that of the embodiment 2, add the TS signal which is originally generated separately from the terrestrial digital television broadcasting, and transmit along with the terrestrial digital television broadcasting.

[Embodiment 8]

[0076] Next, the embodiment 8 will be described. By using a technique of
30 the embodiment 3, the embodiment 8 combines N partially-received part signals of the terrestrial digital broadcasting of N received waves and M original TS signal in one channel to transmit, and specifically, synchronizes symbol timings of the signals of the partially-received parts of each system and the original TS

signals to transmit.

[0077] Fig. 12 is a block diagram illustrating a configuration (embodiment 8) of the retransmitting apparatus of the terrestrial digital broadcasting according to the exemplary embodiment of the present invention. This retransmitting apparatus 8 comprises the receiving antenna unit 100, the N tuning units 200, N 5 digitally-processing units 313, M modulating units 723, a delay time adjusting circuit 307-8, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600. The modulating units 723 are configured with M systems, and each of the systems is configured with the same circuit, so that only 10 one system will be described. The modulating unit 723 includes the OFDM modulating circuit 701, the OFDM framing circuit 702, the reverse Fourier-transforming circuit 703, the GI adding circuit 704, a digitally-delaying circuit 706, and the segment allocating circuit 705. As comparing the retransmitting apparatus 3 of the embodiment 3 illustrated in Fig. 6 with the retransmitting 15 apparatus 8, while both apparatuses are the same in that both apparatuses are provided with the receiving antenna unit 100, the tuning unit 200, the digitally-processing unit 313, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600, both apparatuses are different from each other in that the retransmitting apparatus 8 is provided with the M modulating units 723, 20 and the delay time adjusting circuit 307-8 whose configuration is different from that of the delay time adjusting circuit 307-3 of the retransmitting apparatus 3. In Fig. 12, the same code as that of Fig. 3 is attached to the component which is common to that of Fig. 3, and the detailed description will be omitted below. The OFDM modulating circuit 701, the OFDM framing circuit 702, and the 25 reverse Fourier-transforming circuit 703 of the modulating unit 723 are the same as those of the modulating unit 721 of the retransmitting apparatus 6 illustrated in Fig. 10, so that the detailed description will be omitted.

[0078] The GI adding circuit 704 of the modulating unit 723 inputs the signal of a time area, which is reverse Fourier-transformed by the reverse 30 Fourier-transforming circuit 703, and adds the GI depending on the GI ratio which is previously set. The GI adding circuit 704 outputs the beginning position information of symbols to the delay time adjusting circuit 307-8.

[0079] The delay time adjusting circuit 307-8 inputs the beginning position

information of symbols from the symbol synchronization detecting circuits 304 of the digitally-processing units 313 - 1 to N of each system respectively, inputs the beginning position information of symbols from the GI adding circuits 704 of the modulating units 723 - 1 to M of each system respectively, and calculates a
5 delay time of each system based on the receiving time of any one of the equivalent base band signals so that the symbol beginning timings of the equivalent base band signals of each system correspond to each other.

[0080] The digitally-delaying circuit 706 of each system of the modulating unit 723 inputs the signal of a time area, to which the GI is added by the GI
10 adding circuits 704, inputs a delay time calculated by the delay time adjusting circuit 307-8, and delays by the delay time.

[0081] The segment allocating circuit 705 inputs the signal delayed by the digitally-delaying circuit 706 and converts a frequency to a segment allocated when the signal is combined to one equivalent base band signal.

15 [0082] The adding circuit 400 inputs the equivalent base band signals of the one-segment part, which are digitally-processed by the digitally-processing units 313 of N systems, inputs the equivalent base band signals of the original TS signals modulated by the modulating units 723 of M systems, and adds and synthesizes such equivalent base band signals.

20 [0083] As described above, the retransmitting apparatus 8 of the terrestrial digital broadcasting according to the embodiment 8 can obtain the same advantageous effect as that of the embodiment 3, add the TS signal which is originally generated separately from the terrestrial digital television broadcasting, and transmit along with the terrestrial digital television broadcasting.

25 [0084] The symbol timings of the one-segment part signals and the original TS signals of each system can be synthesized. Thereby, the symbol beginning positions of each of equivalent base band signals can be conformed, so that when the signals are combined as one equivalent base band signal at the adding circuit 400, the signals can be transmitted as synchronizing the symbol synchronization
30 timings.

[Embodiment 9]

[0085] Next, the embodiment 9 will be described. By using a technique of the embodiment 4, the embodiment 9 combines N partially-received part signals

of the terrestrial digital broadcasting of N received waves and M original TS signals in one channel to transmit, and specifically, synchronizes symbol timings and the SP patterns of the partially-received part signals of each system and the original TS signals to transmit.

- 5 [0086] Fig. 13 is a block diagram illustrating a configuration (embodiment 9) of the retransmitting apparatus of the terrestrial digital broadcasting according to the exemplary embodiment of the present invention. This retransmitting apparatus 9 comprises the receiving antenna unit 100, the N tuning units 200, N digitally-processing units 314, the M modulating units 723, a delay time
10 adjusting circuit 307-9, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600. The modulating units 723 are configured with M systems, and each of the systems is configured with the same circuit, so that only one system will be described. As comparing the retransmitting apparatus 4 of the embodiment 4 illustrated in Fig. 7 with the retransmitting
15 apparatus 9, while both apparatuses are the same in that both apparatuses are provided with the receiving antenna unit 100, the tuning unit 200, the digitally-processing unit 314, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600, both apparatuses are different from each other in that the retransmitting apparatus 9 is provided with the M modulating units 723,
20 and the delay time adjusting circuit 307-9 whose configuration is different from that of the delay time adjusting circuit 307-4 of the retransmitting apparatus 4. As comparing the retransmitting apparatus 8 of the embodiment 8 illustrated in Fig. 12 with the retransmitting apparatus 9, both apparatuses are different from each other in that the retransmitting apparatus 9 is provided with the digitally-
25 processing unit 314 and the delay time adjusting circuit 307-9 whose configurations are different from those of the digitally-processing unit 313 and the delay time adjusting circuit 307-8 of the retransmitting apparatus 8. In Fig. 13, the same code as that of Fig. 7 is attached to the component which is common to that of Fig. 7, and the detailed description will be omitted below. The OFDM
30 modulating circuit 701, the OFDM framing circuit 702, and the reverse Fourier-transforming circuit 703 of the modulating unit 723 are the same as those of the modulating unit 723 of the retransmitting apparatus 8 illustrated in Fig. 12, so that the detailed description will be omitted.

[0087] The GI adding circuit 704 of the modulating unit 723 inputs the signal of a time area, which is reverse Fourier-transformed by the reverse Fourier-transforming circuit 703, and adds the GI depending on the GI ratio which is previously set. The GI adding circuit 704 outputs the beginning
5 position information and the SP pattern information of symbols to the delay time adjusting circuit 307-9.

[0088] The delay time adjusting circuit 307-9 inputs the beginning position information and the SP pattern information of symbols from the digitally-processing units 314-1 to N of each system respectively, inputs the beginning
10 position information and the SP pattern information of symbols from the GI adding circuits 704 of the modulating units 723 - 1 to M of each system respectively, and calculates a delay time of each system based on the receiving time of any one of the equivalent base band signals so that the symbol beginning timings and the SP pattern information of the equivalent base band signals of
15 each system correspond to each other.

[0089] The digitally-delaying circuit 706 of each system of the modulating unit 723 inputs the signal of a time area, to which the GI is added by the GI adding circuits 704, inputs a delay time calculated by the delay time adjusting circuit 307-9, and delays by the delay time.

20 [0090] The segment allocating circuit 705 inputs the signal delayed by the digitally-delaying circuit 706, and converts a frequency to a segment allocated when the signal is combined to one equivalent base band signal.

[0091] The adding circuit 400 inputs the equivalent base band signals of the one-segment part, which are digital-processed by the digitally-processing units
25 314 of N systems, inputs the equivalent base band signals of the original TS signals modulated by the modulating units 723 of M systems, and adds and synthesizes such equivalent base band signals.

[0092] As described above, the retransmitting apparatus 9 of the terrestrial digital broadcasting according to the embodiment 9 can obtain the same
30 advantageous effect as that of the embodiment 4, add the TS signal which is originally generated separately from the terrestrial digital television broadcasting, and transmit along with the terrestrial digital television broadcasting.

[0093] The symbol timings and the SP patterns of the one-segment part

signals of each system and the original TS signals can be conformed. Thereby, the symbol beginning positions and the SP patterns of each equivalent base band signal can be conformed, so that when the signals are combined as one equivalent base band signal in the adding circuit 400, the signals can be transmitted as

5 conforming the symbol synchronization timings and also the SP patterns.

[Embodiment 10]

[0094] Next, the embodiment 10 will be described. By using a technique of the embodiment 5, the embodiment 10 combines N partially-received part signals of the terrestrial digital broadcasting of N received waves and M original TS

10 signals to one channel to transmit, and specifically, synchronizes the frame beginning positions of the partially-received part signals of each system and the original TS signals to transmit.

[0095] Fig. 14 is a block diagram illustrating a configuration (embodiment 10) of the retransmitting apparatus of the terrestrial digital broadcasting

15 according to the exemplary embodiment of the present invention. This retransmitting apparatus 10 comprises the receiving antenna unit 100, the N tuning units 200, N digitally-processing units 315, the M modulating units 723, a delay time adjusting circuit 307-10, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600. The modulating units 723 are

20 configured with M systems, and each of the systems is configured with the same circuit, so that only one system will be described. As comparing the retransmitting apparatus 5 of the embodiment 5 illustrated in Fig. 9 with the retransmitting apparatus 10, while both apparatuses are the same in that both apparatuses are provided with the receiving antenna unit 100, the tuning unit 200,

25 the digitally-processing unit 315, the adding circuit 400, the retransmitting unit 500, and the transmitting antenna unit 600, both apparatuses are different from each other in that the retransmitting apparatus 10 is provided with the M modulating units 723, and the delay time adjusting circuit 307-10 whose configuration is different from that of the delay time adjusting circuit 307-5 of

30 the retransmitting apparatus 5. As comparing the retransmitting apparatus 9 of the embodiment 9 illustrated in Fig. 13 with the retransmitting apparatus 10, both apparatuses are different from each other in that the retransmitting apparatus 10 is provided with the digitally-processing unit 315 and the delay time adjusting

circuit 307-10 whose configurations are different from those of the digitally-processing unit 314 and the delay time adjusting circuit 307-9 of the retransmitting apparatus 9. In Fig. 14, the same code as that of Fig. 9 is attached to the component which is common to that of Fig. 9, and the detailed description will be omitted below. The OFDM modulating circuit 701, the OFDM framing circuit 702, and the reverse Fourier-transforming circuit 703 of the modulating unit 723 are the same as those of the modulating unit 723 of the retransmitting apparatus 9 illustrated in Fig. 13, so that the detailed description will be omitted.

10 **[0096]** The GI adding circuit 704 of the modulating unit 723 inputs the signal of a time area, which is reverse Fourier-transformed by the reverse Fourier-transforming circuit 703, and adds the GI depending on the GI ratio which is previously set. The GI adding circuit 704 outputs the beginning position information of frames to the delay time adjusting circuit 307-10.

15 **[0097]** The delay time adjusting circuit 307-10 inputs the beginning position information of frames from the digitally-processing units 315 -1 to N of each system respectively, inputs the beginning position information of frames from the GI adding circuits 704 of the modulating units 723 - 1 to M of each system respectively, and calculates a delay time of each system based on the receiving
20 time of any one of the equivalent base band signals so that the frame beginning timings of the equivalent base band signals of each system correspond to each other.

[0098] The digitally-delaying circuit 706 of each system of the modulating unit 723 inputs the signal of a time area, to which the GI is added by the GI
25 adding circuits 704, inputs a delay time calculated by the delay time adjusting circuit 307-10, and delays by the delay time.

[0099] The segment allocating circuit 705 inputs the signal delayed by the digitally-delaying circuit 706 and converts a frequency to a segment allocated when the signal is combined to one equivalent base band signal.

30 **[0100]** The adding circuit 400 inputs the equivalent base band signals of the one-segment part, which are digital-processed by the digitally-processing units 315 of N systems, inputs the equivalent base band signals of the original TS signals modulated by the modulating units 723 of M systems, and adds and

synthesizes such equivalent base band signals.

[0101] As described above, the retransmitting apparatus 10 of the terrestrial digital broadcasting according to the embodiment 10 can obtain the same advantageous effect as that of the embodiment 5, add the TS signal which is
5 originally generated separately from the terrestrial digital television broadcasting, and transmit along with the terrestrial digital television broadcasting.

[0102] The frame beginning positions of the one-segment part signals of each system and the original TS signals can be conformed. Thereby, the frame beginning positions of each of the equivalent base band signals can be conformed,
10 so that when the signals are combined as one equivalent base band signal at the adding circuit 400, the signals can be retransmitted as conforming the frame synchronization timings, and also the symbol synchronization timings and the SP patterns.

[0103] As described above, while the present invention is described by using
15 the embodiments, the present invention is not limited to the above embodiments, and can be modified in various ways without departing from the scope of the technical concept of the present invention. For example, in the above embodiments, while the receiving antenna unit 100 is configured with one antenna, the receiving antenna unit 100 is not necessarily one, and may be
20 configured with a plurality of antennas. In such a case, each tuning unit 200 inputs the terrestrial digital broadcasting received by any one of the plurality of antennas.

[0104] In the above embodiments, while the receiving-converting circuit 201 of the tuning unit 200 converts a frequency of an inputted signal to an
25 intermediate frequency to pass through a SAW filter as a receiving method with an intermediate frequency, and subsequently, converts a frequency again to a low frequency, the present invention is not limited to such a case. For example, the following methods may be also used: such a Low - IF (low and intermediate frequency) method that the inputted signal is directly converted to
30 low and intermediate frequency signals ranging approximately 0.5 to 1.0 MHz; such a Double-Conversion method that the inputted signal is once converted to a high frequency (e.g. 2 GHz) to be passed through the SAW filter, and subsequently, is converted to a low frequency (e.g. 1 GHz); and such a Direct-

Conversion method that the inputted signal is directly converted to the equivalent base band signal. Regarding a detailed description of the receiving method with an intermediate frequency, refer to "Edition by Mitutoshi Hatori, [One-segment broadcasting text], issued by Impress R & D Corporation".

- 5 [0105] While the above embodiments are intended for the terrestrial digital broadcasting, the present invention may be applied to the terrestrial sound broadcasting.

CLAIMS

1. A retransmitting apparatus of terrestrial digital broadcasting, comprising:
 - a plurality of tuning units;
 - a plurality of digitally-processing units corresponding to the tuning
 - 5 units respectively;
 - an adding unit; and
 - a retransmitting unit,

wherein the retransmitting apparatus receives a plurality of terrestrial digital broadcasting waves configured with a plurality of segments, extracts one

- 10 segment from the terrestrial digital broadcasting waves respectively, and combines the extracted segments to retransmit as a terrestrial digital broadcasting wave,

the tuning unit includes:

 - a receiving-converting means for selecting one broadcasting wave of
 - 15 the plurality of received terrestrial digital broadcasting waves, and converting a RF band signal of the broadcasting wave to a IF band signal;
 - an AD converting means for converting the IF signal converted by the receiving-converting means to a digital IF signal; and
 - an orthogonal-demodulating means for orthogonal-demodulating the
 - 20 digital IF signal converted by the AD converting means, and outputting an equivalent base band signal,

the digitally-processing unit includes:

 - a filtering means for extracting one segment from the equivalent base band signal outputted by the orthogonal-demodulating means of the tuning unit;
 - 25 a symbol synchronization detecting means for detecting a symbol timing, which includes the beginning position information of symbols, and an amount of frequency error for synchronizing symbols for the equivalent base band signal of the one segment extracted by the filtering means;
 - a frequency error correcting means for correcting a frequency error
 - 30 by using the equivalent base band signal of the one segment extracted by the filtering means and the amount of frequency error detected by the symbol synchronization detecting means;
 - a guard interval replacing means for replacing a signal from a first

- position to a third position and a signal from a second position to a fourth position as new guard intervals, when a signal of one symbol length is extracted from the equivalent base band signal by using the equivalent base band signal of the one segment in which said frequency error has been corrected by the
- 5 frequency error correcting means and the symbol timing detected by the symbol synchronization detecting means, and positions which are apart by half a guard interval length from both terminal ends of the extracted signal of one symbol length are designated as the first position and the second position respectively, and positions which are apart by a guard interval length from the both terminal
- 10 ends are designated as the third position and the fourth position respectively; and
- a segment allocating means for converting a frequency of the equivalent base band signal of the one segment, the guard interval of which is replaced by the guard interval replacing means, into predefined band width for combining a plurality of segments,
- 15 the adding unit includes:
- a means for adding and synthesizing the equivalent base band signal of each one segment, a frequency of which is converted by each of the segment allocating means of the plurality of digitally-processing units, and
- the retransmitting unit includes:
- 20 an orthogonal-modulating means for orthogonal-modulating the equivalent base band signal added and synchronized by the adding unit, and outputting the digital IF signal;
- a DA converting means for converting the digital IF signal outputted by the orthogonal-modulating means to an analog IF signal; and
- 25 a transmission-converting means for converting the IF analog signal converted by the DA converting means to the RF band signal to be retransmitted as the terrestrial digital broadcasting wave, and amplifying the converted signal.

2. The retransmitting apparatus of terrestrial digital broadcasting according to
- 30 claim 1, the retransmitting apparatus further comprising:

a delay time adjusting unit for adjusting delay times for synchronizing timings for the equivalent base band signals of the plurality of digitally-processing units,

wherein the digitally-processing unit includes:

instead of said guard interval replacing means, a delaying unit for delaying the equivalent base band signal of one segment by a delay time by using the equivalent base band signal of the one segment in which said frequency error
5 has been corrected by the frequency error correcting means and the delay time adjusted by the delay time adjusting unit, wherein the segment allocating means converts a frequency of the equivalent base band signal of one segment delayed by the delaying unit into a predefined band width for combining a plurality of segments, and

10 the delay time adjusting unit includes:

a means for calculating each of the delay times by using the symbol timings detected by the symbol synchronization detecting means of the plurality of digitally-processing units respectively so that the equivalent base band signals of the digitally-processing units correspond to each other.

15

3. The retransmitting apparatus of terrestrial digital broadcasting according to claim 1, the retransmitting apparatus further comprising:

the delay time adjusting unit for adjusting the delay times for synchronizing timings for each of the equivalent base band signals of the
20 plurality of digitally-processing units,

wherein the digitally-processing unit further includes:

a FFT means for converting a signal of a time area to a signal of a frequency area for the equivalent base band signal of the one segment corrected by the frequency error correcting means;

25 an SP pattern detecting means for detecting an SP pattern for the signal of a frequency area converted by the FFT means; and

instead of said guard interval replacing means, a delaying unit for delaying the equivalent base band signal of one segment by a delay time by using the equivalent base band signal of the one segment in which said frequency error
30 has been corrected by the frequency error correcting means and the delay time adjusted by the delay time adjusting unit, wherein the segment allocating means converts a frequency of the equivalent base band signal of one segment delayed by the delaying unit into a predefined band width for combining a plurality of

segments, and

the delay time adjusting unit includes:

5 a means for calculating each of the delay times by using the symbol timings detected by the symbol synchronization detecting means of the plurality of digitally-processing units respectively, and the SP patterns detected by the SP pattern detecting means of the plurality of digitally-processing units respectively, so that the symbol timings and the SP patterns of the equivalent base band signals of the digitally-processing units are conformed respectively.

10 4. The retransmitting apparatus of terrestrial digital broadcasting according to claim 1, the retransmitting apparatus further comprising:

the delay time adjusting unit for adjusting the delay times for synchronizing timings for each of the equivalent base band signals of the plurality of digitally-processing units,

15 wherein the digitally-processing unit further includes:

the FFT means for converting a signal of a time area to a signal of a frequency area for the equivalent base band signal of the one segment corrected by the frequency error correcting means;

20 a frame synchronization detecting means for detecting a frame timing for synchronizing a frame by using a TMCC signal of the signal of a frequency area converted by the FFT means; and

instead of said guard interval replacing means, a delaying unit for delaying the equivalent base band signal of one segment by a delay time by using the equivalent base band signal of the one segment in which said frequency error has been corrected by the frequency error correcting means and the delay time adjusted by the delay time adjusting unit, wherein the segment allocating means converts a frequency of the equivalent base band signal of one segment delayed by the delaying unit into a predefined band width for combining a plurality of segments, and

30 the delay time adjusting unit includes:

a means for calculating each of the delay times by using the symbol timings detected by the symbol synchronization detecting means of the plurality of digitally-processing units respectively, and the frame timings detected by the

frame synchronization detecting means of the plurality of digitally-processing units respectively, so that the frame timings of the equivalent base band signals of the digitally-processing units are conformed.

- 5 5. The retransmitting apparatus of terrestrial digital broadcasting according to any one of claims 1 to 4, further comprising:
- a plurality of modulating units,
- wherein the modulating unit includes:
- an OFDM modulating means for inputting an original TS signal to
- 10 OFDM-modulate;
- an OFDM-framing means for OFDM-framing the signal OFDM-modulated by the OFDM modulating means;
- a reverse Fourier-transforming means for converting the signal OFDM-framed by the OFDM-framing means from a signal of a frequency area to
- 15 a signal of a time area;
- a guard interval adding means for adding a guard interval to the signal of a time area converted by the reverse Fourier-transforming unit; and
- a segment allocating means for converting a frequency of the signal (equivalent base band signal of the original TS signal) to which the guard
- 20 interval is added by the guard interval adding means into a predefined band width for combining a plurality of segments,
- the adding unit includes:
- a means for adding and synthesizing the equivalent base band signals of each one segment, a frequency of which is converted by the segment
- 25 allocating means of the plurality of digitally-processing units, and the equivalent base band signals of each of the original TS signals, a frequency of which is converted by the segment allocating means of the plurality of modulating units.
- 30 6. The retransmitting apparatus of terrestrial digital broadcasting according to any one of claims 1 to 5,
- wherein one segment extracted by the filtering means of the digitally-processing unit is designated as a segment of a partially-received part of broadcasting for a portable/mobile device or a segment of a terrestrial digital

sound broadcasting.