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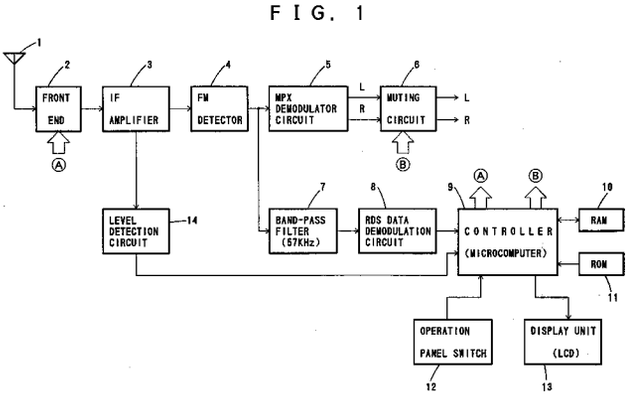
(54) A RDS receiver.

(57) The present invention provides an RDS receiver for use with an automobile which receives data concerning radio broadcasting stations incorporated within a network and is capable of, in case the electric field strength of a radio station currently being received has decreased to less than a predetermined level in some way or other, automatically selecting a radio wave broadcast from another radio station having a higher electric field strength in the same network, wherein the RDS receiver, in automatically changing from a radio station currently being received to another radio station broadcasting the same program, extends or shortens a muting time during which the muting operation is executed, by controlling a station detector (SD) waiting time, which is a required period of time until the SD signal becomes high level, in proportion to a difference between the frequency currently being received and that of another radio station.

In order to complete the above object, the RDS receiver according to the present invention comprises a controlling means to calculate a difference between the frequency currently being received and that of another radio station, and controls an SD (station detector) waiting time in proportion to the thus figured-out difference therebetween.

FIG. 1



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Background of the Invention

Field of the Invention

The present invention relates to an improvement of a radio data system (RDS) receiver for use with an automobile which receives data concerning radio broadcasting stations (hereinafter referred to simply as "radio station") incorporated within a network, and is capable of automatically selecting a radio wave which is broadcast from another radio station having a higher electric field strength than a radio station currently being received within the same network.

Description of the Prior Art

With this radio data system (RDS), a subcarrier of 57 KHz, which is the third harmonic of a 19 KHz stereo pilot signal; a main carrier of FM modulation wave, is amplitude modulated through a suppressed-carrier amplitude modulation method by an RDS signal which is filtered and biphase-coded, and by frequency modulating the thus amplitude modulated subcarrier on the main carrier of FM modulation wave, the RDS data indicative of the names of radio stations, a list of the frequencies by which same programs are being broadcast and so on are multiplexed on a FM audio signal.

A list of the RDS data to be multiplexed is shown in Fig. 4, and a transmitting format of the RDS data is shown in Fig. 5. An RDS receiver decodes the received RDS data of Fig. 4 in accordance with the transmitting format of Fig. 5, and for example in the RDS receiver carried in an automobile, when the moving automobile leaves an area in which a radio station is being received, and a program currently being broadcast from the radio station becomes difficult to be received, then other radio stations broadcasting the same program as that currently being received are automatically selected sequentially one by one on the basis of the frequency list of radio stations in the same network which are included in the RDS data, so that the same program as the one currently being received can be continuously received.

By the way, with the above RDS receiver, in the case that the radio station currently being received is switched to another radio station broadcasting the same program when the receiving sensitivity of the radio station currently being received by the RDS receiver has become poor due to the fact that the automobile leaves away from the receiving area of such radio station and so on, the radio receiver first detects that the electric field strength from the radio station currently being received has been lowered and identifies another radio station broadcasting the same program, and thereafter outputs a PLL data (a tuning voltage (TV) applied to a variable capacitor, which is a direct voltage outputted from the low-pass filter of the PLL) corresponding to the thus identified another radio station, wherein it is checked after a predetermined time of period (normally 16 msec.) from the output of the PLL data whether or not a direct voltage which is an ANDed output from a level detection circuit and an S curve output is at high level, and if it is determined that the direct voltage is at high level, then it is judged that there is a station detector signal (hereinafter referred to simply as an SD signal) and thereby the muting operation is released.

By the way, the muting time, which is a period of time for executing the above muting operation, is a constant value (16 msec) regardless of whether the frequency of a radio station currently being received and that of another station broadcasting the same program are far or near from each other, that is, regardless of whether the respective station detector (SD) waiting time which is a required period of time until the SD signal becomes high level are different from each other. In other words, as shown in Figs. 6A and 6B, since the period between the moment that the output tuning voltage (TV) corresponding to the above another radio station is generated and the moment that the muting operation is released is settled as constant regardless of whether the frequency of a radio station currently being received and that of another radio station broadcasting the same program are far or near from each other, even when a broadcast wave from a radio station of a nearby frequency is selected, the fact still remains that the time for frequency switching process (AF [alternative frequency] checking time), that is, the period for executing the muting operation, is extended.

SUMMARY OF THE INVENTION

The present invention is provided for solving the above problem, and the object of the present invention is to provide an RDS receiver which is capable of shortening the time required for AF checking time, in other words, the time of period during which a muting operation is executed, in case of switching a radio station currently being received to another radio station of the nearby frequency, by setting the muting time on the basis of the SD waiting time; the period of time until the SD signal becomes high level, which SD waiting time being variable in accordance with the distance between the frequency of the station currently being received and that of another radio station which is broadcasting the same program.

In order to attain the above object, the present invention provides an RDS receiver which receives

data concerning radio stations incorporated in the same network and is capable of automatically selecting a radio wave broadcast from another radio station having a higher electric field strength than a radio station currently being received in the same network so as to switch the radio station currently being received to the thus selected another radio station when the electric field strength of the radio station currently being received has decreased, wherein when the radio station currently being received is switched to the above another radio station, the RDS radio receiver calculates a difference between the frequency currently being received and that of the another radio station, and controls an SD (station detector) waiting time which is a required period of time until the SD signal becomes high level in proportion to the thus calculated difference, and thereby controlling the muting time during which a muting operation is executed.

According to another aspect of the present invention, the invention also includes a method of controlling a period of time during which an audio signal muting operation is executed in an RDS receiver which is capable of receiving data multiplexed on a broadcast wave concerning radio stations incorporated in a network, wherein the method comprising the steps of: extracting data concerning radio stations incorporated in a network; storing frequencies of the extracted data in a storing means; detecting a phenomenon that the electric field strength of a radio station currently being received has decreased to a level less than a predetermined level; selecting a frequency from the frequencies of the extracted data; calculating a difference between the frequency of the radio station currently being received and the selected frequency; and sending an instruction signal to a circuit for muting an audio signal for a certain period in proportion to the thus calculated difference.

[Action]

The RDS receiver according to the present invention constructed as above, in the case that the electric field strength of the radio station currently being received has decreased and an electric wave from another radio station having a higher electric field strength than that of the radio station currently being received in the same network is automatically selected to be changed, calculates a difference between the frequency of the station currently being received and that of the above another station, and settles the SD waiting time to control the muting time during which the muting operation is executed in proportion to the thus figured-out difference, so that it shortens the period of time required for frequency changing operation, that is, the period of time for executing the muting operation.

Other objects and features of the invention will be more fully understood from the following detailed description and appended claims when taken in conjunction with the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a block diagram showing one embodiment of the present invention;
Fig. 2 is a flowchart showing the operation of the controller shown in Fig. 1;
Figs. 3A and 3B are illustrations, each explaining a period during which the muting operation is executed according to the present invention;
Fig. 4 is a list of RDS data;
Fig. 5 is a transmission format of the RDS data; and
Figs. 6A and 6B are illustrations, each explaining a period during which the muting operation is executed in the prior art.

In the figures, reference numeral 1 denotes an antenna, numeral 2 denotes a front end, 3 an IF amplifier, 4 an FM detector, 5 an MPX demodulation circuit, 6 a muting circuit, 7 a band-pass filter, 8 an RDS data demodulation circuit, 9 a controller, 10 a RAM, 11 a ROM, 12 an operation panel switch, 13 a display unit, and reference numeral 14 denotes a level detection circuit.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

One embodiment of the RDS receiver according to the present invention is explained referring to Fig. 1 as shown below.

An FM multiplexed broadcast wave from a desired station can be selected at a front end 2 from FM multiplex broadcasts received by an antenna 1 in accordance with an instruction from a controller (later explained) on the basis of the operation of an operation panel switch 12 (explained later on), and the thus selected radio station is supplied to an FM detector 4 by way of an IF (Intermediate frequency) amplifier. The front end 2 is composed, for example, by a PLL synthesizer system which employs a PLL circuit including a programmable frequency divider, the division ratio of which is controlled by a controller 9, the operation of which will be described later, thereby effecting the operation of station selection.

Then, the detected output of the FM detector 4 is supplied to a MPX (multiplex) demodulator circuit 5 to produce audio signals separated into L (left) channel and R (right) channel. These L, R audio signals demodulated by the MPX demodula-

tor circuit 5 are connected to a low frequency amplifier (not shown) by way of a muting circuit 6 which is controlled by the controller 9.

The detected output of the FM detector 4 is also supplied to a band-pass filter 7 of 57 KHz, and by passing through the band-pass filter 7, an RDS data signal, that is, a subcarrier of 57 KHz which is amplitude modulated is sampled and then supplied to an RDS data demodulation circuit 8.

The RDS data demodulation circuit 8 demodulates an RDS signal fed from the 57 KHz band-pass filter 7 and decodes to an original RDS data. This decoded RDS data consists of four 26-bit blocks to form one group as shown in Fig. 5, wherein a start bit of each block, a block identity representative of which one of the blocks in one group the detected block is and so on are defined on the basis of 10-bit offset words assigned to check words of respective blocks, respectively, while at the same time error detection of 16-bit information word is effected on the basis of the check words. The thus decoded RDS data is fed to the controller 9.

The controller 9 includes a microprocessor, which reads the code information of the respective blocks in the RDS data which are inputted sequentially group by group, and stores the information in a RAM 10. The controller 9 controls, on the basis of a station selection command from an operation panel switch 12, the division ratio of the programmable divider of the PLL circuit which is a part of the front end 2, thereby effecting selection of a station. The selected value of receiving-frequency data is stored into the RAM 10.

By the way, a display unit 13 composed of a liquid crystal display means or the like is connected to the controller 9, whereby required information such as the name of the receiving radio station, receiving frequency and so on can be displayed thereon. The processing action of the controller 9 is executed on the basis of the control program stored in a ROM 11.

Further, a detection signal which is outputted from a level detection circuit 14 when the level of the intermediate frequency (IF) signal has become lower than a predetermined level is supplied to the controller 9. In addition, when the controller 9 receives this detection signal, it determines that the receiving condition of the broadcast wave currently being received has become poor, and controls the division ratio of the programmable divider of the front end 2 so as to select another network station broadcasting the same program on the basis of the alternative frequency (AF) information of the network stations previously stored in the RAM 10.

In the following, an operation of the present invention is described on the basis of the above construction with reference to a flow chart shown in Fig. 2.

Since the level detection circuit 14 has detected the electric field strength of the radio station currently being received, a detection signal outputted from the level detection circuit 14 is supplied to the controller 9. The controller 9 detects whether or not the detection signal from the level detection circuit 14 has become lower than a predetermined level (step S1), and if it determines that the electric field strength is less than a predetermined level for a predetermined period of time (the time required for one complete searching cycle of alternative frequency (AF) data), then the controller 9 calculates Δf which is the value obtained by subtracting the AF frequency of the radio station, which is broadcasting the same program as that of the radio station currently being received, from the frequency currently being received (step S2).

By this calculated value Δf, an SD waiting time is figured out so as to set a period of time to be waited by the following equation (step S3);

$$(ms) = 8(ms) + 8 \times \Delta f(MHz)/108.0 - 87.5(MHz),$$

where first ms represents an SD waiting time and stands for a "millisecond" to be waited.

Here, for example, if a width of the total band of the FM broadcast is between 87.5 MHz and 108.0 MHz, and if the frequency of the radio station currently being received is 100 MHz and the AF frequency of another radio station broadcasting the same program as that currently being received is 105 MHz, then the value of Δf becomes 5 MHz, and thereby the SD waiting time will be 9.95 msec. On the other hand, if the frequency of the radio station currently being received is 88 MHz, and the AF frequency of another radio station broadcasting the same program as that currently being received is 105 MHz, then the value of Δf becomes 17 MHz, and thereby the SD waiting time will be 14.63 msec. As shown by these examples, the SD waiting time becomes either extended or shortened depending on whether the distance between the frequency of the station currently being received and the AF frequency of another station which is broadcasting the same program is near or far from each other.

When the SD waiting time is figured out and settled by the controller 9 on the basis of the above equation, PLL output of the AF frequency is fed to the front end 2, and at the same time, an instruction for muting a signal outputted from the MPX demodulation circuit 5 is sent to a muting circuit 6 from the controller 9 (step S4). By this operation, the muting circuit 6 cuts off an output from the MPX demodulation circuit 5.

On the other hand, the controller 9 determines whether the above settled SD waiting time has

lapsed (step S5), and if the time has already passed, it sends a muting operation releasing signal to the muting circuit 6, and release the muting operation (step S6). By this processing, when the station currently being received is changed to another station of a nearby frequency, listeners can receive a broadcast wave of the nearby frequency station in a shorter muting time.

As described above, the SD waiting time can be settled in accordance with the station detecting speed after the tuning voltage (TV) signal is generated by the PLL data output signal as shown in Figs. 3A and 3B, so that the muting period for the alternative frequency (AF) checking operation can be shortened.

[Effect of the Invention]

An RDS receiver according to the present invention calculates a difference between the frequency of the radio station currently being received and that of another radio station broadcasting the same program in the same network, and controls an SD waiting time for a period in proportion to the thus figured-out difference value, whereby in the case that the frequency of the radio station currently being received and that of the above another radio station are near to each other, the alternative frequency (AF) checking time is shortened, and the period during which the muting operation is executed is thus shortened as well.

While the invention has been described with reference to a specific embodiment, the description is illustrating and is not to be construed as limiting the scope of the invention. Various modifications and changes may occur to those skilled in the art without departing from the spirit and scope of the invention as defined by the appended claims.

Claims

1. An RDS receiver which receives data multiplexed on a broadcast wave concerning radio stations incorporated in a network and is capable of, in case the electric field strength of a radio station currently being received has decreased to less than a predetermined level, automatically selecting a radio wave broadcast from another radio station having a higher electric field strength in said same network so as to switch said radio station currently being received to the thus selected another radio station, said RDS receiver comprising;

   means for sampling RDS data including frequencies of radio stations incorporated in a network;

   storing means for storing said sampled frequencies;

   level detection means for detecting a phenomenon that the electric field strength of a radio station currently being received has decreased to a level which is less than a predetermined level;

   controlling means for receiving a detection signal outputted from said level detection means, selecting a frequency of another radio station broadcasting the same program as the station currently being received from said sampled frequencies previously stored in said storing means, calculating a difference between the frequency of said radio station currently being received and said selected frequency, and sending an instruction signal to a muting circuit for muting an audio signal for a certain period in proportion to the thus calculated difference.

2. A method of controlling a period of time during which an audio signal muting operation is executed in an RDS receiver which is capable of receiving data multiplexed on a broadcast wave concerning radio stations incorporated in a network, said method comprising the steps of:

   extracting data concerning radio stations incorporated in a network;

   storing frequencies of said extracted data in a storing means;

   detecting a phenomenon that the electric field strength of a radio station currently being received has decreased to a level less than a predetermined level;

   selecting a frequency from said frequencies of said extracted data;

   calculating a difference between the frequency of the radio station currently being received and said selected frequency; and

   sending an instruction signal to a circuit for muting an audio signal for a certain period in proportion to the thus calculated difference.

3. A method of controlling a period of time during which an audio signal muting operation is executed in an RDS receiver as defined in claim 2, wherein said calculating step is processed on the basis of a formula;

   $(ms) = 8(ms) + 8 \times \Delta f(MHz)/108.0 - 87.5-(MHz)$,

   where ms stands for a millisecond and the first ms represents an station detector waiting time be waited before releasing said muted period, and Δf represents a difference between said frequency of the radio station currently being received and said selected frequency.

FIG. 1

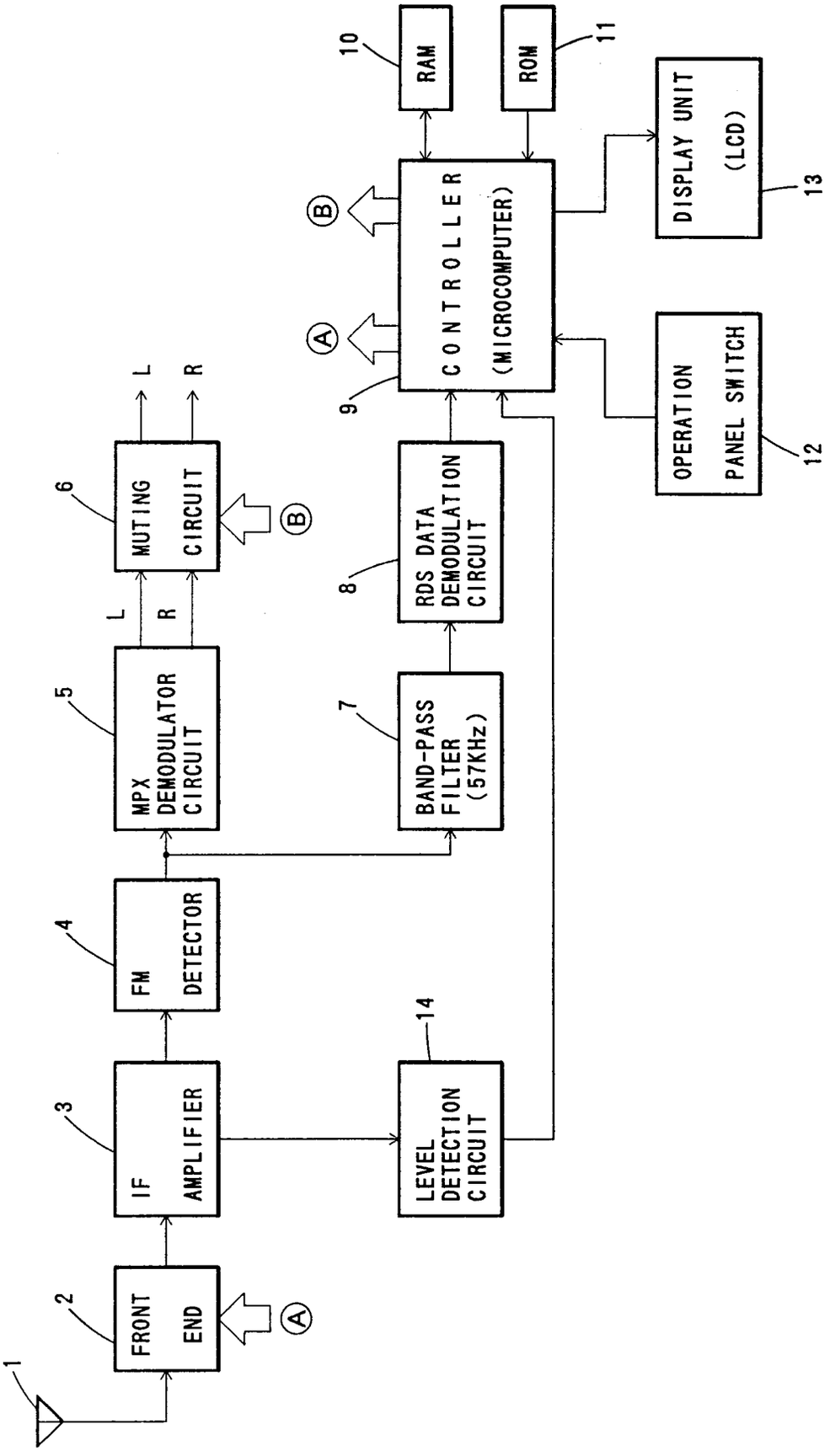
1
2
FRONT END
Ⓐ
3
IF AMPLIFIER
4
FM DETECTOR
5
MPX DEMODULATOR CIRCUIT
L
R
6
MUTING CIRCUIT
Ⓑ
L
R
7
BAND-PASS FILTER (57KHz)
8
RDS DATA DEMODULATION CIRCUIT
9
CONTROLLER (MICROCOMPUTER)
Ⓐ
Ⓑ
10
RAM
11
ROM
12
OPERATION PANEL SWITCH
13
DISPLAY UNIT (LCD)
14
LEVEL DETECTION CIRCUIT

FIG. 2

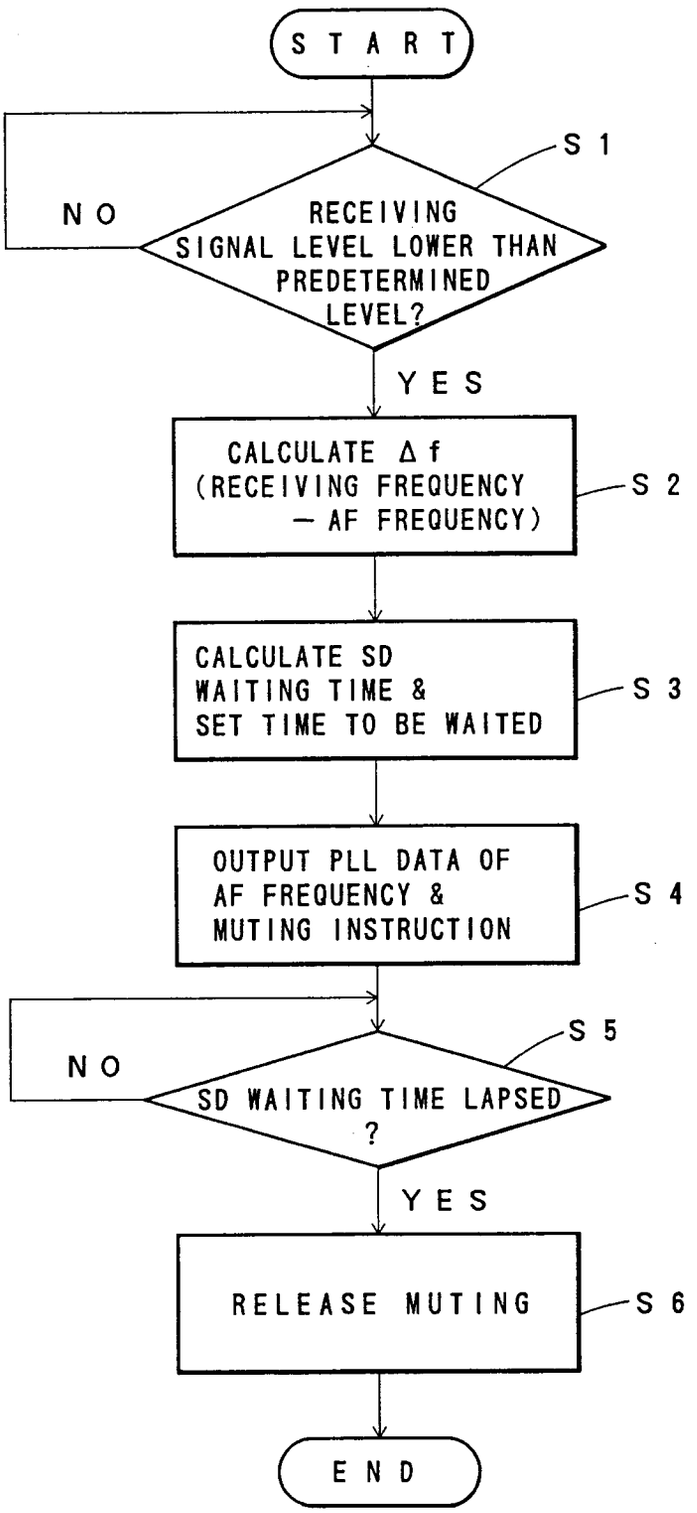
START
S 1
NO
RECEIVING SIGNAL LEVEL LOWER THAN PREDETERMINED LEVEL?
YES
CALCULATE Δf (RECEIVING FREQUENCY − AF FREQUENCY)
S 2
CALCULATE SD WAITING TIME & SET TIME TO BE WAITED
S 3
OUTPUT PLL DATA OF AF FREQUENCY & MUTING INSTRUCTION
S 4
S 5
NO
SD WAITING TIME LAPSED ?
YES
RELEASE MUTING
S 6
END

FIG. 3A

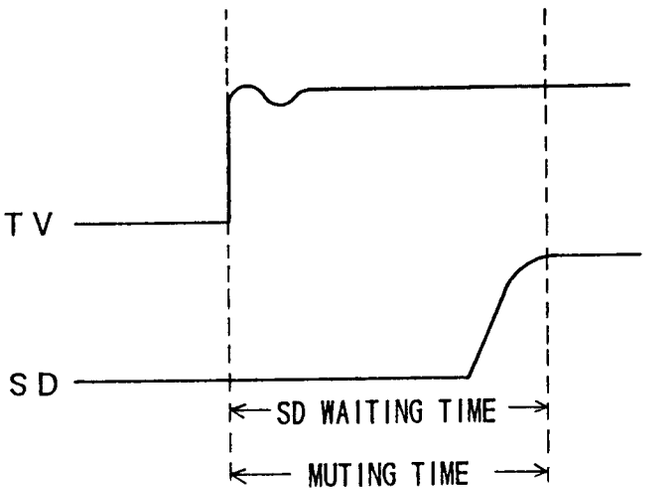
TV
SD
SD WAITING TIME
MUTING TIME

FIG. 3B

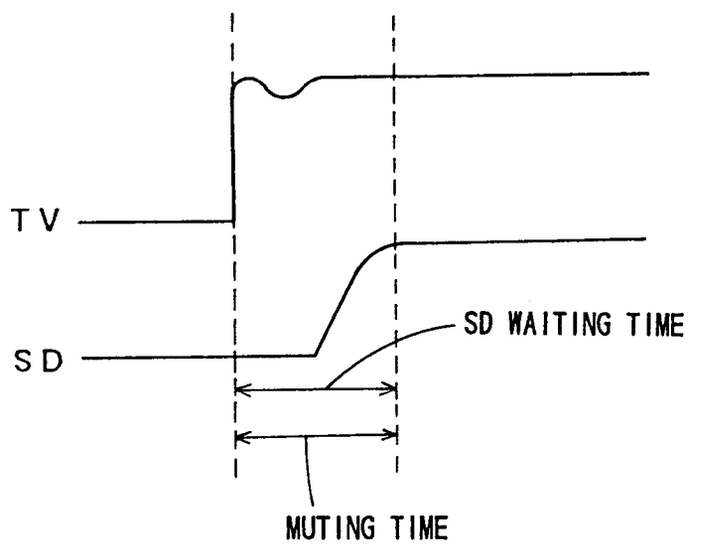
TV
SD
SD WAITING TIME
MUTING TIME

FIG. 4

ABBREVIATION	TITLE	FUNCTION
PI	Program Identification	IDENTIFY COUNTRY, AREA, BROADCASTING STATION
AF	Alternative Frequencies	LIST OF BROADCAST STATIONS IN SAME NETWORK
TP	Traffic Program Identification	IDENTIFY TRAFFIC PROGRAM BROADCASTING STATION
PTY	Program Type	IDENTIFY BROADCAST PROGRAM CONTENT
TA	Traffic Announcement Identification	IDENTIFY TRAFFIC ANNOUNCEMENT
EON	Enhanced Other Network	INFORMATION CONCERNING OTHER NETWORKS
PIN	Program Item Number	BROADCAST STARTING DATE CODE
DI	Decoder Identification	TRANSMISSION MODE IDENTIFICATION CODE
M/S	Music/Speech Switch	MUSIC/SPEECH IDENTIFICATION CODE
PS	Program Service name	STATION NAME CODE IN 8 CHARACTERS
RT	Radio Text channel	TEXT DATA OF 32 OR 64 CHARACTERS
TDC	Transparent Data Channel	DATA SERVICE
RP	Short messages for telephone subscribers	POCKET BELL SERVICE
IH	In-House application	SPECIFIED FOR IN-STATION
TMC	Traffic Message Channel	TRAFFIC MASSAGE SPEECH SYNTHESIZER
CT	Clock Time and date signal	CLOCK INFORMATION

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FIG. 5

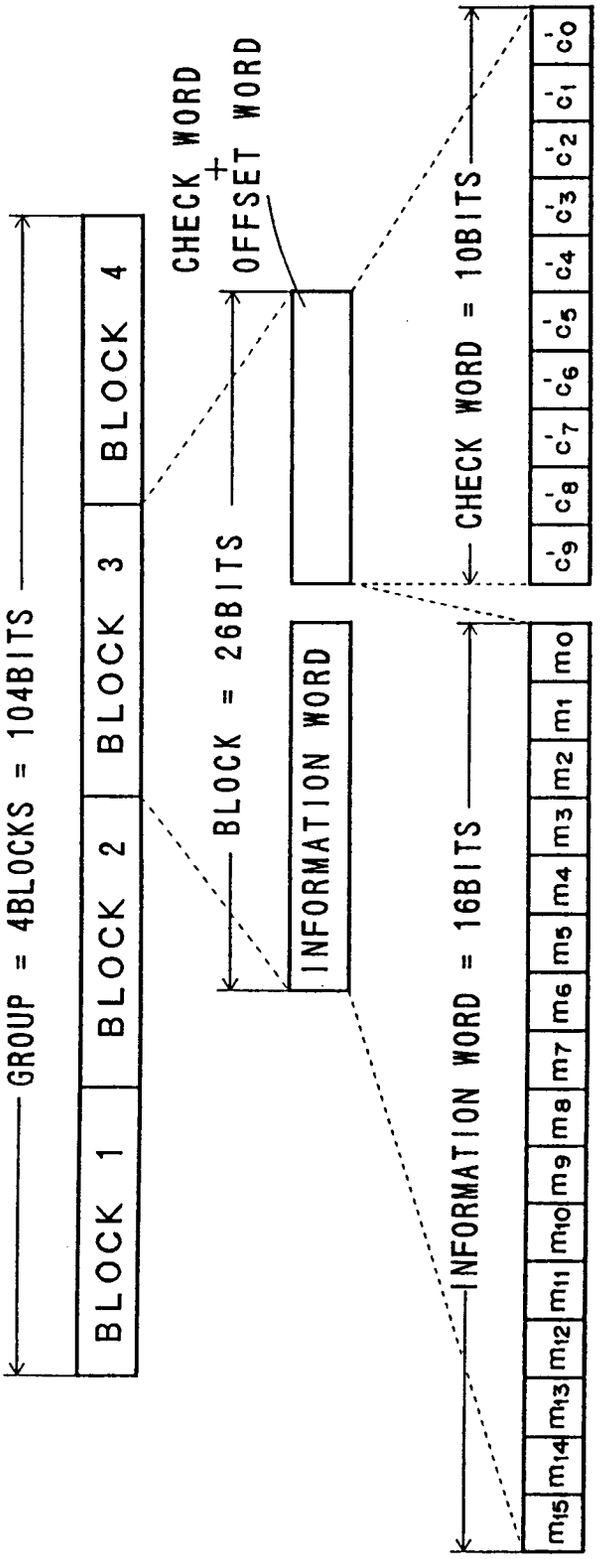

GROUP = 4BLOCKS = 104BITS
BLOCK 1
BLOCK 2
BLOCK 3
BLOCK 4
BLOCK = 26BITS
INFORMATION WORD
CHECK WORD + OFFSET WORD
INFORMATION WORD = 16BITS
CHECK WORD = 10BITS
m15 m14 m13 m12 m11 m10 m9 m8 m7 m6 m5 m4 m3 m2 m1 m0
c'9 c'8 c'7 c'6 c'5 c'4 c'3 c'2 c'1 c'0

FIG. 6A

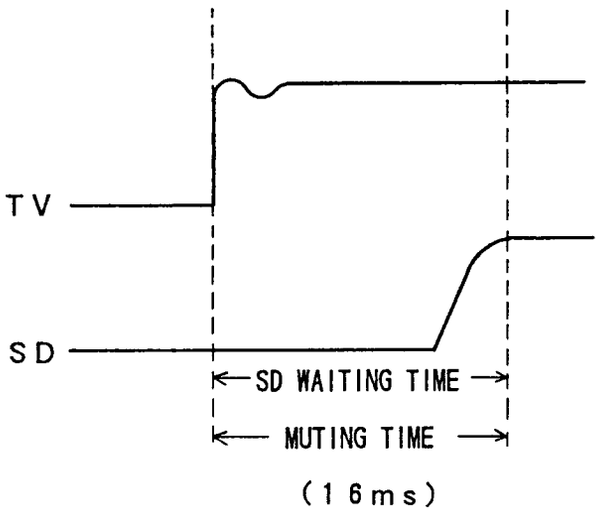
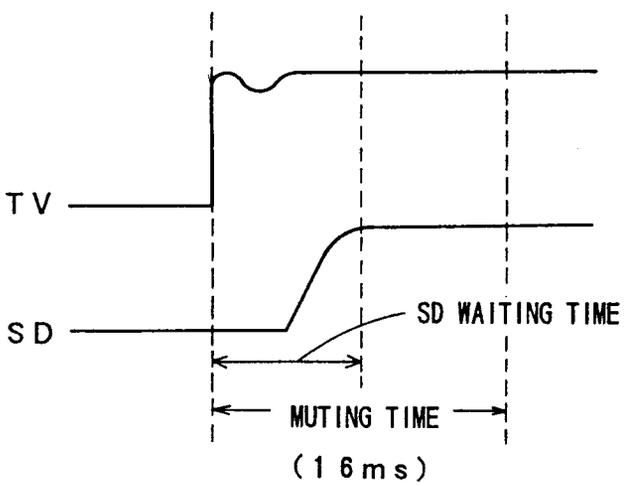

TV
SD
SD WAITING TIME
MUTING TIME
(16ms)

FIG. 6B


TV
SD
SD WAITING TIME
MUTING TIME
(16ms)