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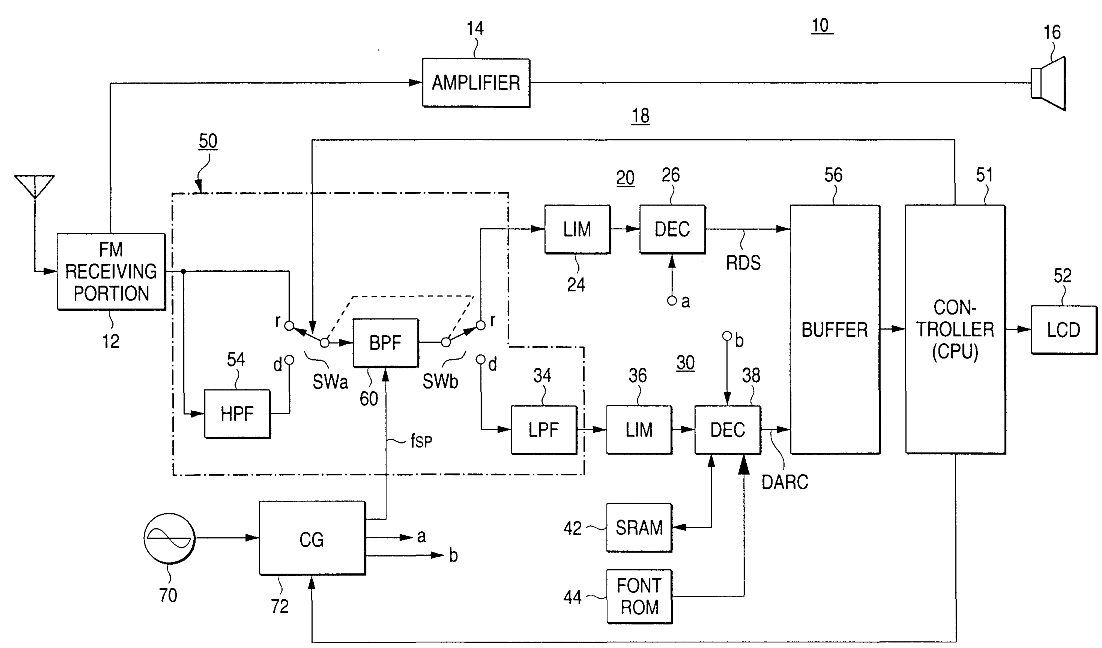
(54) **Receiver for receiving frequency modulated (FM) transmissions, comprising supplementary information transmitted on a subcarrier**

(57) An FM receiver for receiving an FM signal multiplexed with first and second additional information signals (RDS signal and DARC signal) which are different in bit rate. The FM-detected additional information signal is supplied to a common band filter, and the RDS signal extracted by the band filter is supplied to a first decoder system to be decoded while the DARC signal extracted by the band filter is supplied to a second decoder system to be decoded. The pass band characteristic of the band filter is selected so that any of these signals can be extracted on the basis of a selection signal from a controller. The band filter comprises BPF, HPF, LPF and switches SWa, SWb, and only BPF is used as the band-pass filter for the RDS signal.

FIG. 3



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Description

[0001] The present invention relates te an FM receiver, and more particularly to an FM receiver having decoder systems for decoding two types of additional information signals having different sub carriers as multiplexed data relating to FM multiplexed broadcast signals, in which a band-pass filter for extracting the two types of additional information signals is designed to be commonly usable, thereby reducing the circuit scale and the cost of the FM receiver.

[0002] In Europe, particularly in European areas such as Germany, France, and Switzerland, additional services using sub carriers of FM signals are provided. An additional information signal used as an additional service is an RDS (Radio Data System) signal, and services such as a traffic information service, a time display service, and a broadcast station display service, are supplied and utilized as a part of radio information.

[0003] Fig. 1 shows the relationship among various frequency bands of FM signals, the RDS signal, etc. As shown in Fig. 1, the RDS service (signal) area is located in a higher band area than the main channel MCH and the sub channel SCH of the FM broadcast, and it is an additional information signal having an integer-times frequency of the FM pilot frequency fp as a sub carrier. The sub carrier frequency (fsa) is selectively set to 3fp=3X19kHz=57kHz.

[0004] Sufficient service information cannot be supplied to users by using the RDS signal because the bit rate of the RDS signal is equal to 1.1875kbps, and thus an additional service having a higher bit rate is proposed at present. This additional information signal as this new additional service is called as "DARC" (Data Radio Channel) signal, and the frequency spectrum thereof has as an occupational band a frequency band which is higher than and adjacent to that of the RDS signal as shown in Fig. 1. The sub carrier frequency (fsb) thereof is selectively set to four times of the FM pilot frequency fp (4fp=76kHz).

[0005] If the broadcast of the DARC signal as the new additional service is started, it is preferable that an FM receiver can receive both of the RDS signal and the DARC signal.

[0006] Fig. 2 shows the construction of an FM receiver which is designed to receive both of these new and old additional service signals (Fig. 2 shows an example of the FM receiver 10). The FM receiver 10 includes an FM receiving portion 12 for receiving an FM signal at a selected FM channel and subjecting the FM signal thus received to FM demodulation processing. The FM signal thus demodulated (demodulated signal) is amplified by an amplifier 14 and then output from a speaker 16.

[0007] A part of the FM signal thus received (i.e., a part of the FM-detected signal) is further supplied to a decoder system 18 for extracting additional information signals. The decoder system 18 includes a decoder 20 for the RDS signal, a decoder 30 for the DARC signal and a controller 51 comprising a microcomputer for selecting any of these additional information signals or selecting only desired data on the basis of an instruction of a user. The data (traffic information, time data, etc.) thus selected are displayed on a display unit, in this case, a liquid crystal display (LCD) 52.

[0008] The RDS signal decoder 20 has a center frequency of 3fp and includes a band-pass filter (BPF) 22 having high Q (quality factor: oscillation sharpness). By the band-pass filter 22, only the RDS signal of the FM detection signal is extracted, separated and then output. The RDS signal thus extracted is subjected to waveform shaping processing through which the signal level of the RDS signal is limited to a desired level by a limiter 24.

[0009] Thereafter, the RDS signal is supplied to a decoder 26 and a clock fCKa from a clock source 28 is supplied to the decoder 26 to perform decode processing on data contained in the RDS signal. The RDS data thus decoded are supplied to the controller 51 to perform display processing on target data. A clock frequency of 8fsa=456kHz is used as the above clock fCKa to obtain pulses having a duty ratio of 50%.

[0010] Furthermore, the DARC signal decoder 30 has a center frequency of 4fp, and has a band-pass filter 32 having relatively moderate Q. The DARC signal is extracted in the band-pass filter 32. Since there is such a risk that a part of an FM signal at an adjacent channel to the DARC signal is contaminated into the DARC signal thus extracted, the adjacent FM signal is removed by the low-pass filter 34. Thereafter, the DARC signal is subjected to the wave shaping processing to limit the signal level thereof by a limiter 36.

[0011] Thereafter, the DARC signal is supplied to the decoder 38 and a clock fCKb from a clock source 40 is supplied to the decoder 38 to subject data contained in the DARC signal to the decode processing. In this decode processing, a working memory, for example, SRAM 42 is used to perform deinterleave processing on the DARC data, and a font ROM 44 is used to convert the DARC data to display data. As in the case of the RDS data, the DARC data are supplied to the controller 51, and only the target data selected by a user are displayed on the display unit 52. The frequency of the clock fCKb used for the decoding processing is set to 7.2MHz.

[0012] As described above, at least two reception systems (first decode system 20 and second decode system 30) are required to be provided in order to receive both of the RDS signal and the DARC signal, and particularly when the RDS signal decoder 20 is designed in an IC structure, at least two chips, that is, one chip for the band-pass filter 22 and the other chip for other circuits must be prepared.

[0013] Likewise, when the decoder 30 for the DARC signal is designed in the IC structure, as in the case of the RDS signal decoder 20, not only a chip for the band-pass filter 32, but also a chip for a circuit system containing a limiter 36, a low-pass filter 34 and a decoder 38, a chip for SRAM 42 functioning as a working memory and a chip for ROM 44 in which font data are stored, that is, totally at least four chips are needed to be prepared.

[0014] Therefore, when two signal decode systems are provided, the occupational chip area occupied on a circuit board (i.e., the area of chips which occupy the circuit board) (the area corresponding to at least six chips) is increased, and thus it is not possible to reduce the circuit scale. Further, as the number of chips is increased, a large number of input/output ports of a system microcomputer for controlling both the functions are needed. Therefore, a more multi-functional microcomputer for a receiver than a currently-used microcomputer for a receiver must be used, resulting in an increase of the cost.

[0015] Therefore, the present invention has been implemented to overcome the above problem of the prior art, and has an object to provide an FM receiver in which the number of chips can be reduced and thus the area of a board can be reduced by designing a band-pass filter so that it is commonly usable as much as possible, thereby reducing the cost of the FM receiver.

[0016] In order to solve the above problem, an FM receiver according to the claim 1 in this invention is an FM receiver for receiving FM signals in which first and second addition information signals having different bit rates are multiplexed, and is characterized in that the FM-detected additional information signals are supplied to a common band filter, the first additional information signal extracted by the band filter is supplied to a first decoder system to be decoded, and the second additional information signal extracted by the band filter is supplied to a second decoder system to be decoded, and that the band filter is designed so that the pass band characteristic thereof is selected so that any additional information signal can be extracted on the basis of a selection signal from a controller.

[0017] In the present invention, the band-pass filter for extracting the RDS signal and a part of the band-pass filter for extracting DARC signal are made common for use. That is, the band-pass filter for extracting the RDS signal is used as a part of the band-pass filter of the DARC signal. The DARC signal band-pass filter comprises three filters of a high-pass filter for picking up signals in higher frequency bands than that of the DARC signals, a band-pass filter for extracting the DARC signal and a low-pass filter for removing adjacent channel signals, and the band-pass filter thereof is commonly used. Only one clock source for supplying clocks to the band-pass filter is used.

[0018] By commonly using the band-pass filter, only one filter chip is provided, so that the chip area is reduced and thus the circuit scale can be reduced. Since the number of input/output ports of the microcomputer is reduced, a microcomputer being currently used can be applied, and the cost of installation into the apparatus can be reduced.

[0019] An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a frequency characteristic diagram of additional information signals multiplexed with an FM signal;
Fig. 2 is a diagram showing the construction of the FM receiver for receiving the additional information signals;
Fig. 3 is a systematic diagram of a main part showing an embodiment of an FM receiver according to the present invention;
Fig. 4 is a connection diagram of a band-pass filter used to explain the principle of the band-pass filter;
Fig. 5 is a diagram showing a response characteristic of a frequency band;
Fig. 6 is an explanatory diagram of an SCF filter;
Fig. 7 is an equivalent circuit diagram of the SCF filter; and
Fig. 8 is a connection diagram of a main part showing the embodiment of a band-pass filter usable in the present invention.

[0020] Fig. 3 shows the construction of an FM receiver 10 as an embodiment.

[0021] As is apparent from Fig. 3, the FM receiver 10 according to the present embodiment has an RDS signal decoder 20 and a DARC signal decoder 30. An RDS signal or a DARC signal which is demodulated in the RDS signal decoder 20 or the DARC signal decoder 30 is supplied through a buffer circuit 56 to a controller 51 comprising a microcomputer, and only additional information selected by a user is displayed on a display unit 52 comprising an LCD or the like and supplied as a service to the user.

[0022] Both the decoders 20, 30 are designed in the same structure as the prior art, and thus the RDS signal decoder 20 has a decode portion 26, and the DARC signal decoder 30 has a decode portion 38. It is the same as the prior art that the deinterleave processing is carried out by using a working SRAM 42 and the decode processing of additional information is carried out by using font data stored in ROM 44.

[0023] Additional information signals (RDS signal and/or DARC signal) which are FM-detected by an FM receiving portion 12 are supplied to a band filter 50 to extract and separate a desired additional information signal. Therefore, the band filter 50 has a band-pass filter 60, a first switch SWa is provided at the front stage of the filter 60, and one terminal r thereof is directly supplied with the FM-detected additional information signal while the other terminal d thereof is supplied with the FM-detected additional information signal through a high-pass filter 54.

[0024] A second switch SWb is provided at the output stage side of the band-pass filter 60, and one terminal r side thereof is connected to a limiter 24 constituting the RDS signal decoder 20 while the other terminal d side thereof is connected to a limiter 36 constituting the DARC signal decoder 30 through a low-pass filter 34.

[0025] The first and second switches SWa and SWb are switched interlockingly with each other. Fig. 3 shows a switch state when the RDS signal is selected. An electronic switch is used for each of the switches SWa and SWb, and a switching signal therefor is generated in the controller 51. Only the band-pass filter 60 is used when the RDS signal is extracted.

[0026] On the other hand, when the DARC signal is extracted, the high-pass filter 54, the band-pass filter 60 and the filter 34 are used. First, signals in higher frequency bands which are above the frequency band of the DARC signal are extracted by the high-pass filter 54, then the frequency band of the DARC signal is extracted by the band-pass filter 60 therefrom and then the signal components of channels adjacent to the DARC signal are removed through the low-pass filter 34.

[0027] The above band-pass filter 60 functions as a narrow-band filter having a center frequency of 3fp for the RDS signal, and also functions as a wide-band filter having a center frequency of 4fp for the DARC signal. For this purpose, the frequency of a clock to be used (driving clock) may be varied between the narrow-band filter and the wide-band filter. In this case, the clock of 2.7MHz is used for the RDS signal, and the clock of 3.6MHz is used for the DARC signal.

[0028] This is because if the clock of 2.7MHz (switching pulses) is used, it functions as a band filter having a narrow-band characteristic having a center frequency of 57kHz on the basis of the construction of the band-pass filter 60 described later. Likewise, if the clock of 3.6MHz is used, it functions as a band filter having a wide-band characteristic having a center frequency of 76kHz.

[0029] In order to obtain such clocks, a single clock source 70 is provided, and a reference clock thereof is supplied to a clock generator 72. In this case, the frequency of the reference clock is selectively set to 10.8MHz which corresponds to the least common multiple of the clock frequency for the RDS signal and the clock frequency for the DARC signal.

[0030] The reference clock is supplied to the clock generator 72 to generate the clocks of 2.7MHz and 3.6MHz. In addition to these clocks, decode processing clocks to be used in the decoders 26 and 38 are generated. In this embodiment, the decode processing is carried out with the same decode processing clock in both the decoders, and thus for example, the clock of 3.6MHz is commonly used. Of course, different clocks may be used as the decode processing clocks for these decoders. In this case, the corresponding decode processing clocks are supplied to the terminals a and b. It is determined on the basis of a selection signal from the controller 51 which clock should be supplied to the band-pass filter 60 in the clock generator 72.

[0031] The band-pass filter 60 is required to change its pass band characteristic in accordance with the type of the additional information signal to be used as described above. In addition to the band width, a Q (quality factor) characteristic is required to be considered for the pass band characteristic. That is, as shown in Fig. 1, since the RDS signal is a narrow-band signal, the band width of the band-pass filter 60 for the RDS signal is narrow and the quality factor Q is high. On the other hand, since the DARC signal is a wide-band signal, the band width of the band-pass filter 60 for the DARC signal is wide and the quality factor Q is relatively low.

[0032] A bi-quad type band-pass filter is preferably used as a band-pass filter whose pass band characteristic is variable in consideration of the band width and Q. As shown in Fig. 4, the band-pass filter is an active filter using three operational amplifiers 64, 66 and 68.

[0033] When a signal is input to the terminal 62a, the band width and Q of the output signal obtained at the output terminal 62b are as follows.

[0034] First, resistors connected to a signal line pass are represented by R1 to R4, and a capacitor is represented by C. The gain G and the band width B of this feedback type active filter are given as follows:

$$G = R2/R1 \tag{1}$$

$$B = 1/(R2 \cdot C) = 1/Q \tag{2}$$

At that time, the cut-off frequency f0 is given as follows:

$$f0 = \frac{1}{2\pi}\sqrt{\frac{1}{R3R4C^2}} \tag{3}$$

Here, Q represents a quality factor.

[0035] Accordingly, it is apparent from (equation 2) that as the resistor (resistance) R2 is increased, Q becomes larger (higher), and also it is apparent from (equation 3) that as the resistor (resistance) R3 is increased, the cut-off frequency f0 is lowered. That is, as both the resistors R2, R3 are increased, a pass band characteristic as shown at the left-hand side of Fig. 5 (the center frequency is lowered, but Q is increased) is obtained.

[0036] Conversely, it is apparent from (equation 2) that Q is reduced (lowered) as the resistor R2 is reduced, and also it is apparent from (equation 3) that the cut-off frequency f0 is increased as the resistor R3 is reduced. Accordingly, as both the resistors R2, R3 are reduced, a pass band characteristic as shown at the right-hand side of Fig. 5 (the center frequency is increased, but Q falls down) is obtained, and thus this relationship is just approximate to the pass band characteristic of the band-pass filter corresponding to the RDS signal and the DARC signal. Furthermore, SCF (switched capacitor filter) is known as a filter. As shown in

[0037] Fig. 6, the SCF filter has a condenser (capacitor) CR which is connected in parallel between the input/output terminals 74a, 74b, and the capacitor CR is connected to a variable terminal side of a switch SWc connected to one transmission path. The switch SWc is controlled to be alternately switched on the basis of a switching pulse SP from the terminal 76. The switching pulse SP is a pulse having a duty ratio of 50%.

[0038] As described above, when the switch SWc is subjected to switching control by using the switching pulse SP of the duty ratio of 50%, it is known that the equivalent circuit at that time becomes one in which the resistor Rc is connected to the transmission path as shown in Fig. 7. At this time, the relationship between the switching frequency fsp and the equivalent resistance Rc is represented as follows:

$$Rc = 1/(fsp \cdot CR) \qquad (4)$$

[0039] As a result, it is apparent that the value of the equivalent resistor Rc is lowered as the switching frequency fsp is increased, and the value of the equivalent resistor Rc is increased as the switching frequency fsp is reduced.

[0040] Accordingly, if the SCF filter is used in place of the resistors R2 and R3 shown in Fig. 4 and also the switching frequency fsp is made variable, the values of the resistors R2 and R3 may be freely variable. By varying the value of the resistor R2, Q of the pass band characteristic of the band-pass filter can be freely varied, and by varying the value of the resistor R3, the cutoff frequency f0 can be adjusted.

[0041] That is, when the resistors R2, R3 are substituted by the SCF filter as shown in Fig. 5 and the value of the equivalent resistor Rc corresponding to R2, R3 is increased by lowering the switching frequency fsp, a pass band characteristic which is a narrow-band characteristic and has high Q (a pass band characteristic at the left-hand side of Fig. 5) can be obtained.

[0042] Furthermore, by increasing the switching frequency fsp and lowering the value of the equivalent resistor Rc, a pass band characteristic which is a wideband characteristic and has relatively low Q (a pass band characteristic at the right-hand side of Fig. 5) can be obtained, whereby there can be fabricated the band-pass filter 60 which can extract the RDS signal of Fig. 1 or extract the DARC signal by setting the switching frequency fsp to a suitable value.

[0043] Fig. 8 shows a concrete example of the band-pass filter 60 based on the above consideration. A first SCF filter SCFa corresponds to a resistor (variable resistor) R2 and is constructed by a capacitor C2 and a switch S2, and the switching pulse SP (fsp) is given to the terminal 80. Likewise, a second SCF filter SCFb corresponds to a resistor (variable resistor) R3 and is constructed by a capacitor C3 and a switch S3, and a switching pulse SP (fsp) which is commonly used is given to the terminal 82.

[0044] When the band-pass filter 60 is used as a filter for extracting the RDS signal, the first switching frequency fspa (=2.7MHz) is supplied, and when it is used as a filter for extracting the DARC signal, the second switching frequency fspb (=3.6MHz) is supplied.

[0045] As described above, according to the present invention, the band-pass filter is designed so as to be commonly used. That is, the band-pass filter for extracting the first additional information signal is also usable as a part of the band-pass filter for the second additional information signal.

[0046] By making the band-pass filter usable commonly, it is sufficient to provide only one filter chip. Therefore, the occupation area of the chip can be reduced and thus the circuit scale can be also reduced. The number of input/output ports of the microcomputer as the controller can be reduced, so that a microcomputer being currently used can be applied and the cost of the installation into the apparatus can be lowered.

[0047] Accordingly, the present invention is extremely preferably applied to an FM receiver for receiving additional information signals such as an RDS signal and a DARC signal which are multiplexed in FM signal and different in frequency band.

Claims

1. An FM receiver, for receiving an FM signal multiplexed with at least one of first and second additional information signals, comprising:

    FM reception means for receiving the FM signal;
    band-pass filter means arranged to be supplied with signals containing at least one of the first and second additional information signals which are FM-detected by said FM reception means;
    first decode means arranged to be supplied with an output signal from said band-pass filter means and which can extract the first additional information signal; and
    second decode means arranged to be supplied with an output signal from said band-pass filter means and which can extract the second additional information signal,

    wherein said band-pass filter means is designed so that the pass band characteristic thereof is selectable so as to extract the first or second additional information signal.

2. An FM receiver as claimed in claim 1, wherein the first additional information signal is an RDS signal and the second additional information signal is a DARC signal.

3. An FM receiver as claimed in claim 1 or 2, further including control means for supplying said band-pass filter means with a selection signal for selecting the pass band characteristic of said band-pass filter means.

4. An FM receiver as claimed in claim 1, 2 or 3, wherein said band-pass filter means is designed so that the pass band characteristic thereof is variable by changing a clock frequency supplied thereto.

5. An FM receiver as claimed in any one of the preceding claims, further including a clock generator for generating first and second clock frequencies to be supplied to said band-pass filter means, said clock generator being connected to a common clock source.

6. An FM receiver as claimed in any one of the preceding claims, wherein said band-pass filter means comprises a band-pass filter, a high-pass filter which is connected to said band-pass filter through a first switch provided at the front stage thereof, and a low-pass filter which is connected to said band-pass filter through a second switch provided at the rear stage of said band-pass filter.

7. An FM receiver as claimed in claim 6 when appendant to claim 3, wherein said first and second switches perform the selection operation on the basis of the selection signal supplied from said control means.

8. An FM receiver as claimed in claim 6 or 7, wherein said band-pass filter is designed so that the pass band characteristic thereof is variable by changing a clock frequency supplied to said band-pass filter.

9. An FM receiver as claimed in claim 8, further including a clock generator for generating first and second clock frequencies to be supplied to said band-pass filter, said clock generator being connected to a common clock source.

FIG. 1

DESCRIPTION OF RDS AND DARC SIGNALS

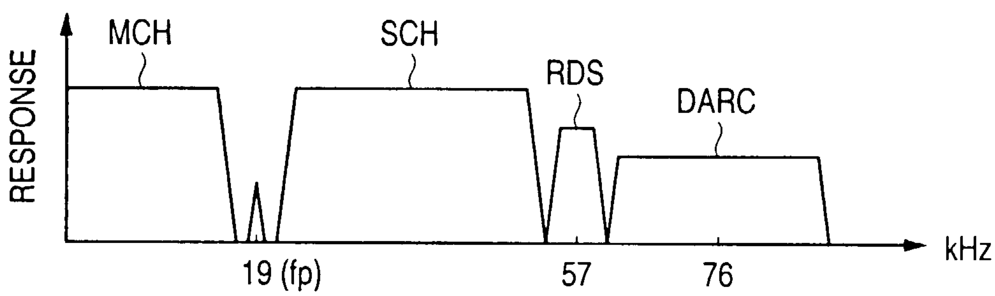
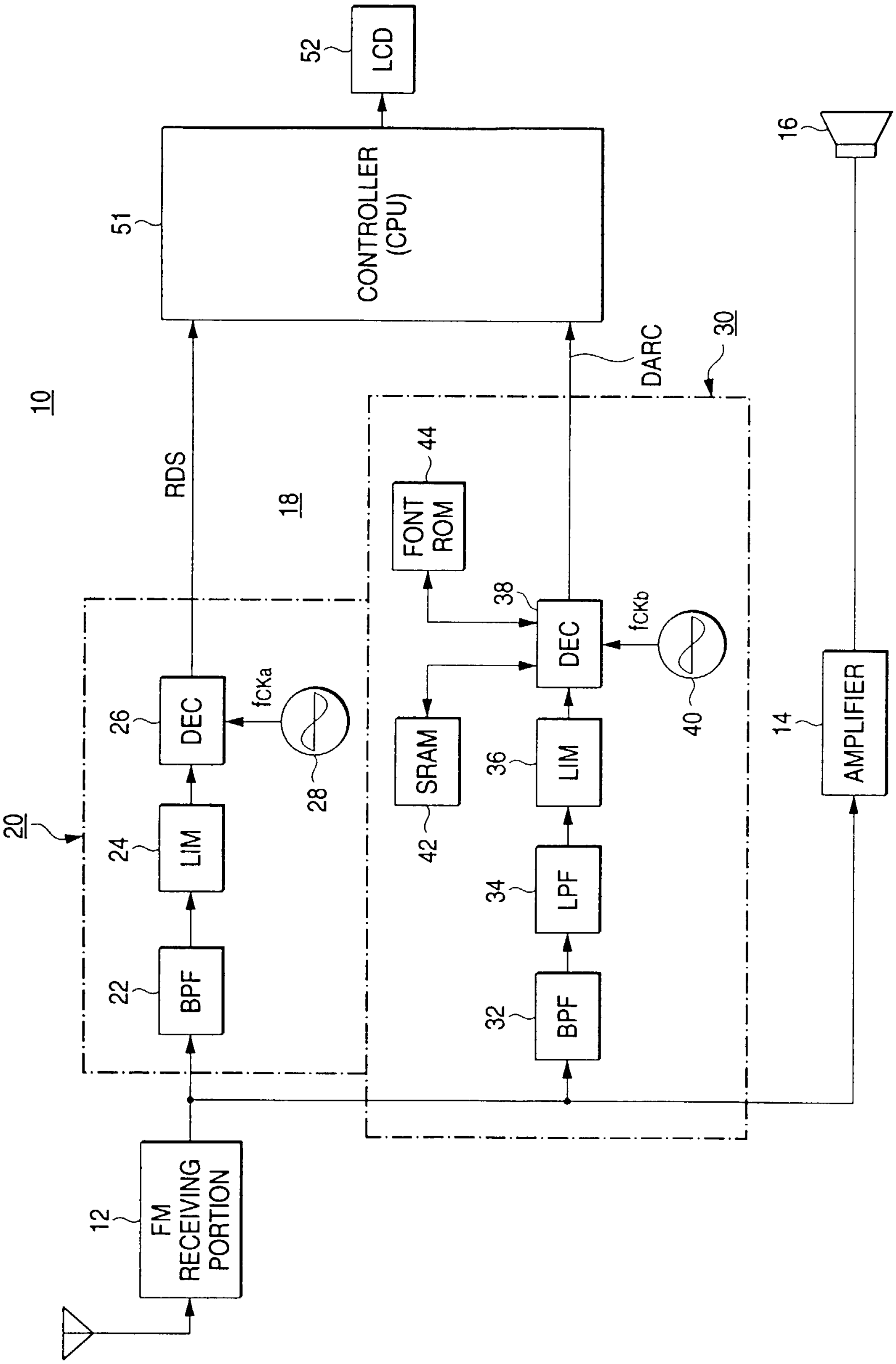


FIG. 2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FM RECEIVING PORTION
12
20
BPF
22
LIM
24
DEC
26
fCKa
28
RDS
18
CONTROLLER (CPU)
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LCD
52
30
DARC
FONT ROM
44
SRAM
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BPF
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LPF
34
LIM
36
DEC
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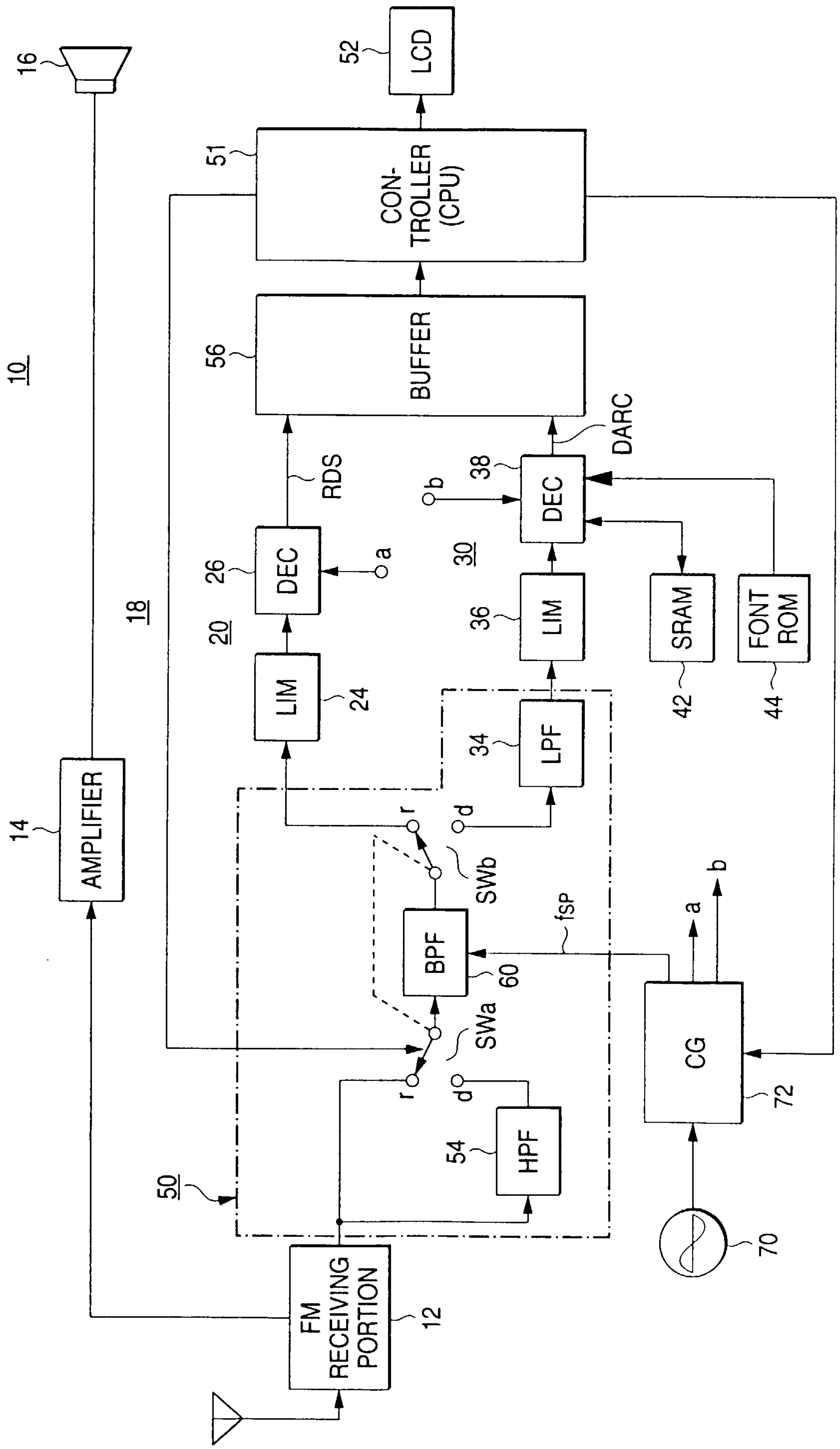
fCKb
40
AMPLIFIER
14
16

FIG. 3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RDS
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52
LCD
30
LPF
34
LIM
36
DEC
38
b
DARC
SRAM
42
FONT ROM
44
50
HPF
54
SWa
SWb
r
d
BPF
60
fSP
CG
72
70

FIG. 4

DESCRIPTION OF BAND FILTER

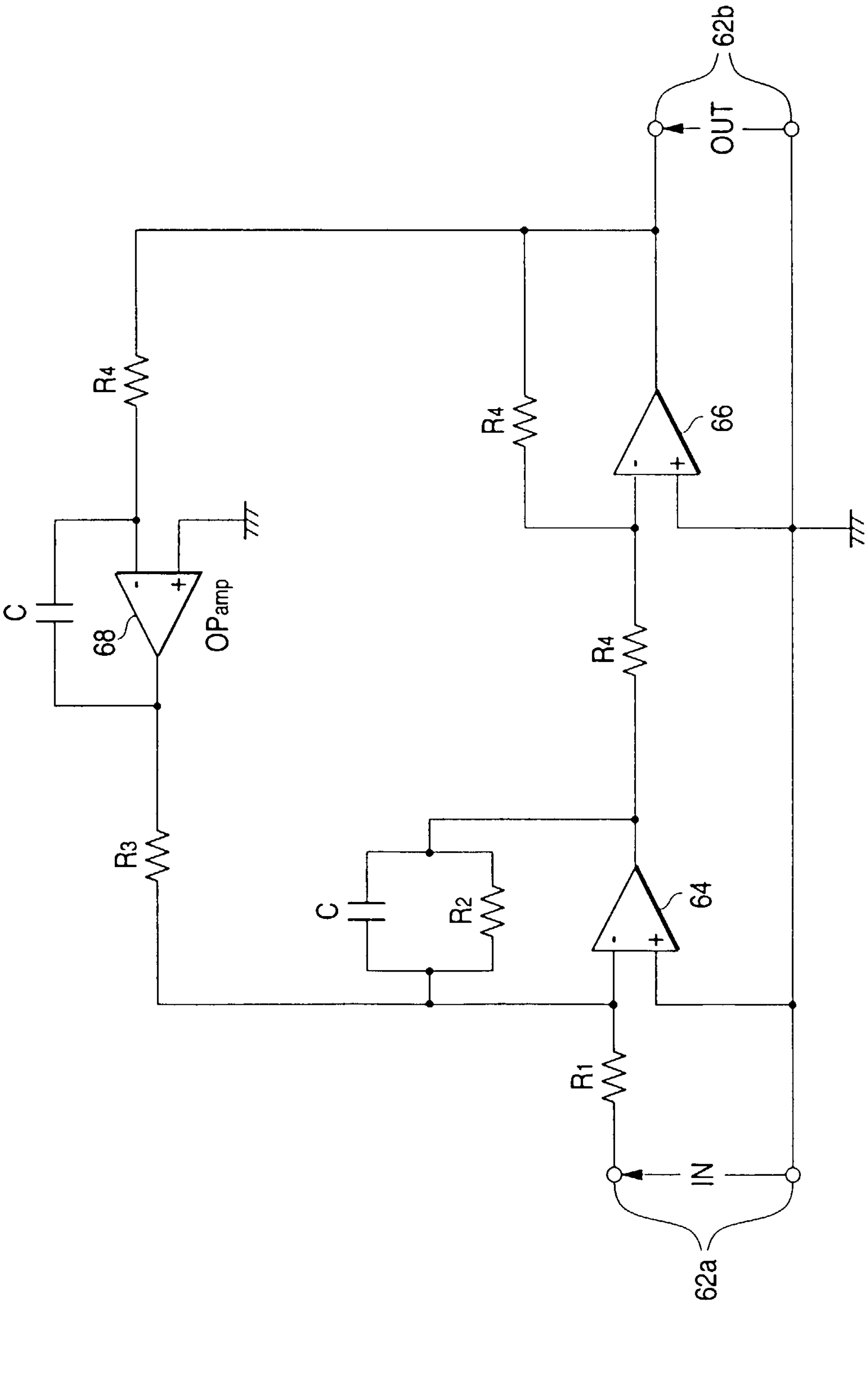


FIG. 5

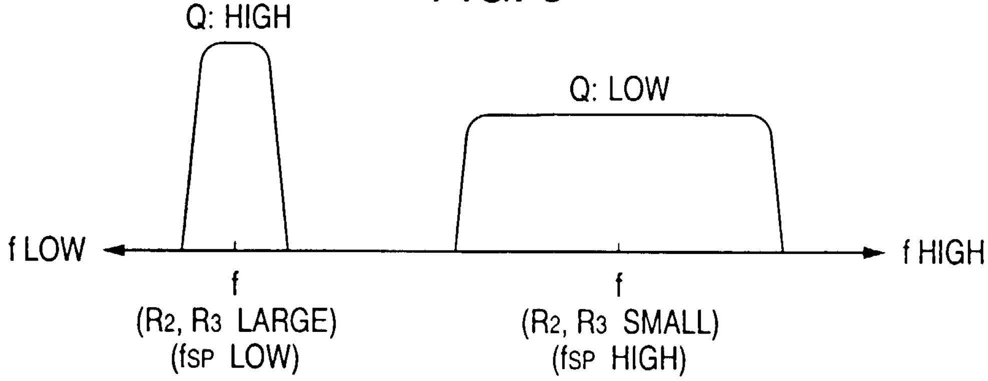


FIG. 6

DESCRIPTION OF SCF

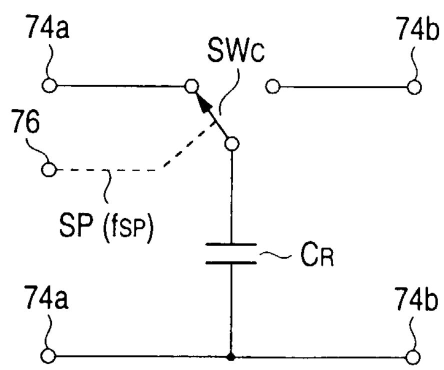


FIG. 7

EQUIVALENT CIRCUIT OF SCF

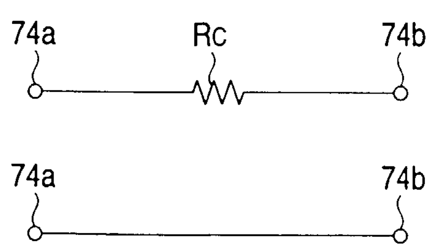
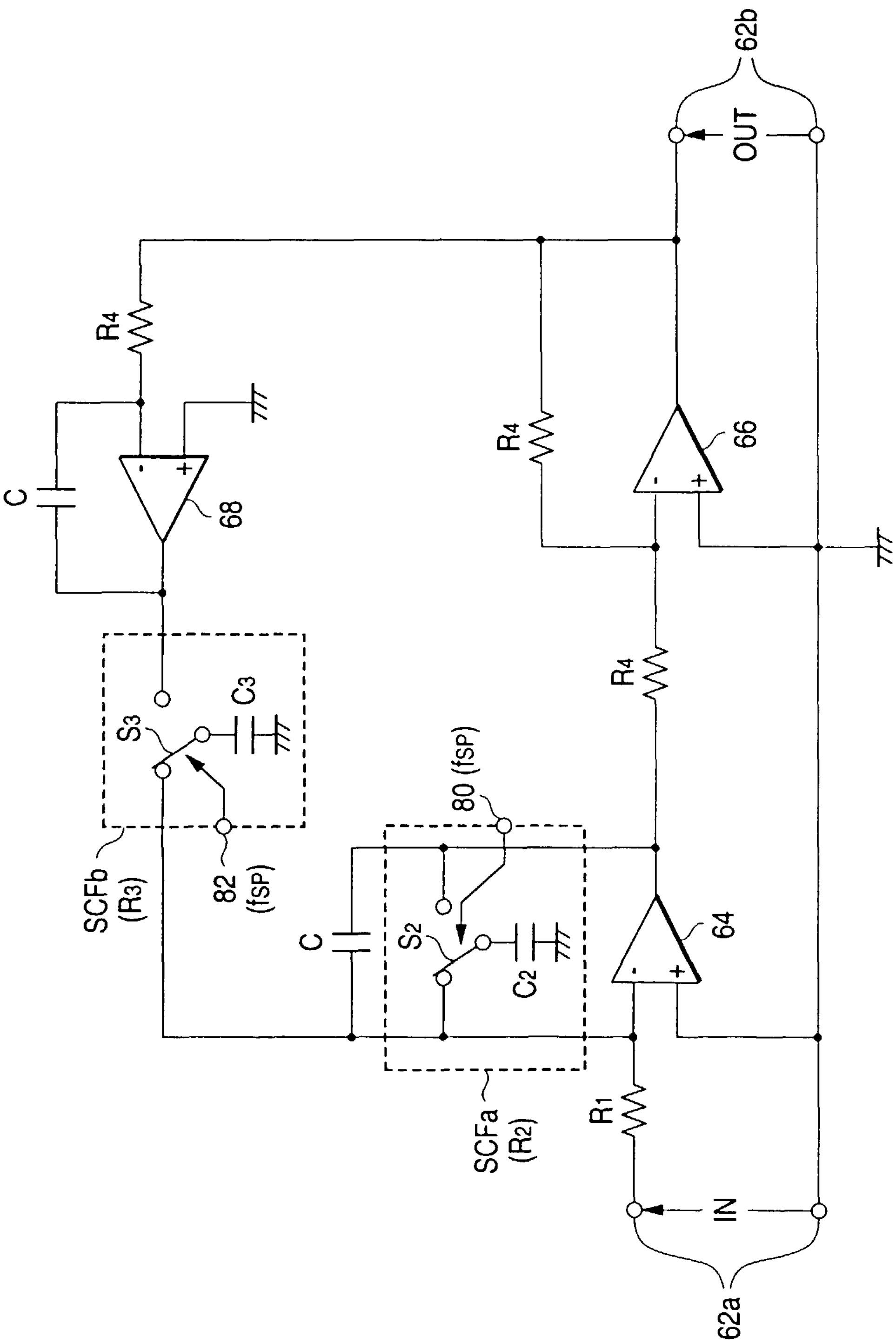


FIG. 8

60


62b
OUT
R4
R4
66
C
68
R4
C3
S3
SCFb
(R3)
82
(fSP)
80 (fSP)
C
S2
C2
64
R1
SCFa
(R2)
IN
62a