

(19) Japan Patent
Office (JP)

(12) **Japanese Unexamined Patent
Application Publication (A)**

(11) Japanese Unexamined Patent
Application Publication Number

H8-228118

(43) Publication date: 03 Sep 1996

(51) Int. Cl. ⁶	ID codes file no.	JPO	FI	Theme codes (reference)
H03G 3/20			H03G 3/20	C
H04B 1/16			H04B 1/16	R
H04Q 7/14			7/26	103C
Request for examination: None		Number of claims: 2		FD (Total of 27 pages)
(21) Application number	JP H7-291992 A	(71) Applicant	000001443 Casio Computer Co., Ltd. 2-6-1 Nishi Shinjuku, Shinjuku-ku, Tokyo-to	
(22) Date of application	12 Oct 1995	(72) Inventor	Masaaki ARIMA % Casio Computer Co., Ltd. Hamura Technical Center, 3-2-1 Sakae-cho, Hamura-shi, Tokyo-to	
(31) Priority claim number	JP H6-334304 A	(72) Inventor	Kenji SUZUKI % Casio Computer Co., Ltd. Hamura Technical Center, 3-2-1 Sakae-cho, Hamura-shi, Tokyo-to	
(32) Priority date	15 Dec 1994	(72) Inventor	Toshiaki OTSUKA % Casio Computer Co., Ltd. Hamura Technical Center, 3-2-1 Sakae-cho, Hamura-shi, Tokyo-to	
(33) Priority claim country	Japan (JP)			

(54) [Title of the Invention] Automatic Gain Control Circuit

(57) [Abstract]

[Problem] The present invention relates to automatic gain control circuits, and provides an automatic gain control circuit which improves intermodulation characteristics of an amplification circuit used in a radio receiver such as a pager, and minimizes power consumption in the radio receiver.

[Solution] A bias voltage which is output to an RF amplifier 22 by a bias control AGC circuit 41 is controlled until an excessive current signal is input, and when the excessive current signal is input into an input attenuation AGC circuit 42, an attenuation diode 43 is turned on by the bias voltage and a current signal which is input through an antenna 21 is split via the attenuating diode 43, thus attenuating the current signal which is input into the RF amplifier 22.

Detailed Description of the Invention

[0001] [Technical Field of the Invention] The present invention relates to automatic gain control circuits, and more particularly relates to an automatic gain control circuit disposed inside a radio receiver such as a pager.

5 [0002] [Prior Art] In conventional radio receivers such as pagers, a reception unit is provided with an automatic gain control circuit which adjusts a signal level of a signal output by an RF amplifier output so as to be substantially constant by adjusting the gain of the RF amplifier in response to fluctuations in signal levels of radio signals at specific frequencies (desired wave frequency signals) emitted by base stations.

10 [0003] The configuration in FIG. 8, for example, has existed. In FIG. 8, a radio signal received by an antenna 1 is converted into a current signal and output to an RF amplifier 2. This current signal is amplified by the RF amplifier 2 and output to a mixer 4 after what are known as interfering wave frequency signals other than the desired wave frequency are removed by a bandpass filter 3.

[0004] The current signal which is input into the mixer 4 has its frequency reduced by a local signal
15 which is input from a local oscillator 5 and is then output to the bandpass filter 6. The current signal which is input into the bandpass filter 6 is output to an IF amplifier 7 after the interfering wave frequency signals are once again removed.

[0005] The current signal input into the IF amplifier 7 is amplified and output to a detection circuit
20 8 and an AGC circuit 9. The current signal input into the detection circuit 8 has the carrier wave component removed, and the demodulated signal is extracted and output to a later-stage signal processing unit.

[0006] The AGC circuit 9 controls a bias voltage output to the RF amplifier 2 in response to fluctuations in the current signal input from the IF amplifier 7. Specifically, when an excessive current signal is input, the AGC circuit 9 controls the bias voltage which is output to the RF
25 amplifier 2 and reduces the gain of the RF amplifier 2.

[0007] Furthermore, as shown in FIG. 9, a method also exists in which an AGC amplifier 10 and an attenuation unit 11 are provided instead of the AGC circuit 9 shown in FIG. 8, and the gain of

the RF amplifier 2 is controlled by attenuating beforehand the current signal which is output from the antenna 1 to the RF amplifier 2. Specifically, in the attenuation unit 11, an AC component is removed by a capacitor C from the current signal which is input from the AGC amplifier 10 and the bias voltage of the DC voltage corresponding to the amplitude of the current signal is applied to a diode D via a resistor R.

[0008] Accordingly, when an excessive current signal is input into the AGC amplifier 10, the diode D is turned on by the bias voltage, the current signal input from the antenna 1 is split via the diode D of the attenuation unit 11, and current progression input into the RF amplifier 2 is attenuated.

[0009] [Problem to Be Solved by the Invention] However, with this type of conventional automatic gain control circuit, in the case of the circuit shown in FIG. 8, if an excessively large radio signal is input from the antenna 1, for example, the AGC circuit 9 reduces the bias voltage of the RF amplifier 2 to reduce the gain of the RF amplifier 2, and this is known to affect the intermodulation characteristics of the RF amplifier 2 (harmonic wave amplification circuit) as shown in FIG. 10.

[0010] FIG. 10 is a graph showing input/output characteristics of the three-dimensional distortion component of an interfering wave signal and a desired wave signal amplified by the RF amplifier 2. The lower limit of an input level e_i at which the desired wave signal of the RF amplifier 2 can be received is the input level ea_0 corresponding to the intersection a_0 between the input/output characteristic curve A_0 of the desired wave signal and the output level e_n shifted upward by the requisite S/N from the noise level. Furthermore, the upper limit of the interfering wave signal input level e_i at which the desired wave signal of the RF amplifier 2 can be received is the input level eb_0 corresponding to the intersection b_0 at which the noise level and the output characteristic curve B_0 of the three-dimensional distortion component of the interfering wave signal intersect.

[0011] Furthermore, the dynamic range R_0 of the RF amplifier 2 is represented by the area from the input level ea_0 to the input level eb_0 . Assuming an excessively large radio signal is input from the antenna 1 and the gain of the RF amplifier 2 has been shifted by x decibels by the AGC circuit 9, the input/output characteristic curve A_0 of the desired wave signal and the input/output characteristic curve B_0 of the interfering wave signal become the curves A_d and B_d indicated by

the dotted lines in FIG. 10. The dynamic range R_d of the RF amplifier 2 is similarly represented by the area from the input level ead to the input level ebd.

[0012] As can be seen from FIG. 10, the dynamic range R_d after the gain of the RF amplifier 2 has been reduced by x decibels has deteriorated by $2/3$ decibel compared to the dynamic range R_0 prior to gain reduction. Accordingly, the intermodulation characteristics of the RF amplifier 2 become worse.

[0013] in other words, in the case of the circuit using the bias control method shown in FIG. 8, the gain of the RF amplifier 2 is controlled by reducing the bias current applied to the RF amplifier 2, and therefore power consumption of the circuit can be reduced, which is an advantage, but if the gain of the RF amplifier 2 falls to or below a certain level, the dynamic range of the RF amplifier 2 falls below the dynamic range of the receiver overall, causing the dynamic range of the receiver overall to deteriorate (i.e., not be improved) relative to the three dimensional distortion component of the interfering wave signal, which is a problem.

[0014] Furthermore, because the automatic gain control circuit in a pager has as an object to suppress three-dimensional distortion waves, bias control methods are inappropriate, which is why circuits using an input attenuation method as shown in FIG. 8, which is effective against the three-dimensional distortion components in interfering wave signals, have been used. However, power must continuously be supplied to the AGC amplifier 10, which increases power consumption and reduces the battery life of the pager, which is a problem.

[0015] Accordingly, the present invention was devised in light of these problems and has as an object to provide an automatic gain control circuit capable of minimizing power consumption in a radio receiver such as a pager without affecting the intermodulation characteristics of the RF amplifier used in the radio receiver.

[0016] [Means for Solving the Problem] An automatic gain control circuit achieves this object by being provided with an amplification circuit which amplifies a reception signal and disposed inside a radio receiver which outputs to a later stage the reception signal which has been amplified by the amplification circuit, and comprising a bias control means for controlling a bias voltage level

applied to the amplification circuit until the signal strength of the reception signal reaches a predetermined value, and an attenuation means for attenuating the input level of the reception signal which is input into the amplification circuit once the signal strength of the reception signal has reached or exceeded the predetermined value.

5 [0017] With the automatic gain control circuit of the invention as in claim 1, in a radio receiver provided with an amplification circuit which amplifies a reception signal, a bias voltage level applied to the amplification circuit is controlled until the signal strength of the reception signal has reached a predetermined value, and once the signal strength of the reception signal has reached or exceeded the predetermined value, the input level of the reception signal which is input into the
10 amplification circuit is attenuated. Accordingly, the input level of the reception signal which is input into the amplification circuit is attenuated in lieu of bias control whenever the signal strength of the reception signal is at or above a predetermined level, which makes it possible to improve the intermodulation characteristics of the reception unit and simultaneous to reduce power consumption.

15 [0018] In this case, it is also possible, when the signal strength of the reception signal has reached or exceeded the predetermined value, for the bias control means to hold the bias voltage level which was in effect when the predetermined value was reached, as with the automatic gain control circuit as claimed in claim 2, for example.

[0019] With the automatic gain control circuit as claimed in claim 2, the bias control means carries
20 out control such that when the signal strength of the reception signal has reached or exceeded a predetermined value, the bias voltage level which was in effect when the predetermined value was reached is held. Accordingly, the bias voltage level which is in effect at the predetermined level is held whenever the signal strength of the reception signal the reception level [SIC] is at or above a predetermined level, and therefore the adverse effects on the timing of switching between bias
25 control and input level control are mitigated.

[0020] [Embodiments] On automatic gain control circuit according to the present invention is described below with reference to the drawings.

(First embodiment) FIG. 1 and FIG. 2 are diagrams showing a first embodiment in a case in which an automatic gain control circuit according to the present invention is applied to a pager. A configuration is described first. FIG. 1 is a circuit block diagram of a reception unit 40 of a pager according to the first embodiment.

5 [0021] In this diagram, the reception unit 40 of the pager is configured by an antenna 21, an RF amplifier 22, a bandpass filter 23, a mixer 24, a local oscillator 25, a bandpass filter 26, an IF amplifier 27, a detection circuit 28, a bias control AGC circuit 41, an input attenuation AGC circuit 42, and an attenuation diode 43.

[0022] The antenna 21 receives a radio signal transmitted wirelessly from a pager service company
10 not shown in the drawings, converts it into a current signal, and outputs it to the RF amplifier 22. The RF amplifier 22 amplifies the current signal which is input from the antenna 21 using a predetermined amplification ratio and outputs the result to the bandpass filter 23. The bandpass filter 23 removes the interfering wave frequency signal mixed into the amplified current signal which is input from the RF amplifier 22 in the frequency range of the received radio signal and
15 outputs the result to the mixer 24.

[0023] The local oscillator 25 outputs to the mixer 24 a local signal for reducing the frequency of the current signal which is input into the mixer 24. The mixer 24 uses the current signal which is input from the local oscillator 25 to reduce the frequency of the current signal which is input from the bandpass filter 23, and outputs the result to the bandpass filter 26. The bandpass filter 26
20 removes the interfering wave frequency signal mixed into the current signal which is input from the mixer 24 in the intermediate frequency range within which the frequency of the current signal has been reduced by the mixer 24, and outputs the result to the IF amplifier 27.

[0024] The IF amplifier 27 amplifies the current signal which is input from the bandpass filter 26 using a predetermined amplification ratio and outputs the result to the detection circuit 28 and a
25 signal strength detection unit 29. The detection circuit 28 removes the carrier wave component from the amplified current signal which is input from the IF amplifier 27, extracts the demodulated signal, and outputs the result to a later-stage signal processing unit.

[0025] The bias control AGC circuit 41 controls the bias voltage output to the RF amplifier 22 in response to fluctuations in the current signal which is input from the IF amplifier 27. Specifically, the bias control AGC circuit 41 reduces the gain of the RF amplifier 22 by controlling the bias voltage output to the RF amplifier 22 when an excessive current signal has been input.

5 [0026] The input attenuation AGC circuit 42 and the attenuation diode 43 are circuits which control the gain of the RF amplifier 22 by attenuating ahead of time the current signal output from the antenna 21 to the RF amplifier 22. Specifically, the attenuation diode 43 applies a bias voltage of a DC voltage corresponding to the amplitude of the current signal to the the current signal which is input from the input attenuation AGC circuit 42.

10 [0027] Accordingly, when an excessive current signal is input into the input attenuation AGC circuit 42, the attenuation diode 43 is turned on by the bias voltage, the current signal which is input from the antenna 21 is split by the attenuation diode 43, and the current signal which is input into the RF amplifier 22 is attenuated.

[0028] operation in the present embodiment is described. In FIG. 1, first when a radio signal
15 (desired wave signal) is received from the antenna 21, it is converted into a current signal and output to the RF amplifier 22 where it is amplified by a predetermined amplification ratio, before being output to the bandpass filter 23. In the bandpass filter 32 [SIC], the amplified current signal which is input from the RF amplifier 22 has the interfering wave frequency signals removed in the frequency band received before being output to the mixer 24.

20 [0029] In the mixer 24, the frequency of the current signal which is input from the bandpass filter 23 is reduced to a predetermined intermediate frequency by a local signal which is input from the local oscillator 25, and the result is output to the bandpass filter 26. The interfering wave frequency signals are removed from the current signal which is input into the bandpass filter 26 in the intermediate frequency band and the result is output to the IF amplifier 27.

25 [0030] The current signal which is input into the IF amplifier 27 is amplified at the predetermined amplification ratio and the result is output to the detection circuit 28, the bias control AGC circuit 41, and the input attenuation AGC circuit 42. The bias control AGC circuit 41 and the input

attenuation AGC circuit 42 according to the present embodiment operate in accordance with the input level of the desired wave signal which is input into each, the operating characteristics of the AGC circuits 41, 42 being as shown in the intermodulation characteristics diagram in FIG. 2.

[0031] Specifically, in the bias control AGC circuit 41, a control system needs to be set so as to stop operation to prevent the dynamic range of the RF amplifier 22 from falling to or below the dynamic range of the overall reception unit (i.e., place a limit on its effect).

[0032] In the case of the first embodiment, the input attenuation AGC circuit 42 operates in response to desired wave signals exceeding this limit (the effect limit level of the bias control AGC circuit 41) (the range between the the diagonal lines moving up and to the left in FIG. 2), thereby attenuating the current progression which is input into the RF amplifier 22 and improving the intermodulation characteristics as shown in FIG. 2.

[0033] Specifically, if only the bias control AGC circuit 41 is used in the reception unit 40, when the input level of the desired wave signal e_i exceeds the effect limit level of the AGC circuit 41, the dynamic range of the RF amplifier 22 falls below the dynamic range of the reception unit 40 overall, resulting in deterioration of the dynamic range of the reception unit 40 overall relative to the three dimensional distortion components of the interfering wave signal, worsening the intermodulation characteristics.

[0034] However, because the reception unit 40 according to the present embodiment is connected to the input attenuation AGC circuit 42 and is set so that the input attenuation AGC circuit 42 starts working after the bias control AGC circuit 41 reaches its effect limit, the dynamic range of the RF amplifier 22 is prevented from falling below the dynamic range of the reception unit 40 overall, thereby preventing a worsening of the intermodulation characteristics.

[0035] Accordingly, even in cases where a desired wave signal is input exceeding the effect limit level of the bias control AGC circuit 41, a worsening of the intermodulation characteristics can be prevented by operation of the input attenuation AGC circuit 42, making it possible to improve the intermodulation characteristics of the pager equipped with the reception unit 40 according to the present embodiment.

[0036] (Second embodiment) FIG. 3 is a diagram showing a circuit configuration of an automatic gain control circuit 50 according to the second embodiment to which the present invention is applied. In FIG. 3, the automatic gain control circuit 50 is configured by an attenuator circuit 51 configured by a capacitor C1 and a diode D1, a current control circuit 52 configured by resistors R1, R2, and RF amplification circuit 53 configured by a transistor Q1 and an LC resonance circuit, bias capacitors C2, C3, a coupling capacitor C4, and low voltage division resistor R3.

[0037] The attenuator circuit 51 receives input of a desired wave signal received using an antenna which is not shown in the drawings and input of an AGC signal (an auto gain control signal) from a control circuit which is not shown in the drawings. The diode D1 is turned on by the impedance of the AGC signal which is input from the control circuit being reduced in accordance with the field strength of the desired wave, the desired wave signal which is input from the antenna is attenuated a predetermined amount, and the result is transmitted to the RF amplification circuit 53 via the current control circuit 52.

[0038] The current control circuit 52 reduces the base current of the transistor Q1 in the RF amplification circuit 53 using the resistors R1, R2 and reduces the gain of the transistor Q1 when the field strength of the desired wave becomes stronger and the impedance of the AGC signal falls, and turns on the diode D1 inside the attenuator circuit 51 by raising the potential on the resistor R1 side.

[0039] The RF amplification circuit 53 uses the transistor Q1 and the LC resonance circuit to amplify the desired wave signal which is input via the attenuator circuit 51 and the current control circuit 52 a predetermined amplification ratio, and the result is output to the next signal processing circuit via the coupling capacitor C4.

[0040] operation of the second embodiment is described. First, when the field strength of the desired wave received from the antenna is weak, the AGC signal is set to high impedance by the control circuit. At this point, no current is flowing to the resistor R1 in the current control circuit 52, and a bias current corresponding to the bias voltage set by dividing the power voltage V_{cc} by

the voltage division resistor R3 and the resistor R2 in the current control circuit 52 is supplied to the base electrode of the transistor Q1 in the RF amplification circuit 53.

[0041] Furthermore, at this point, the terminal-to-terminal voltage of the diode D1 of the attenuator circuit 51 is 0 V, and therefore the amount of attenuation of the input desired wave signal into the RF amplification circuit 53 of the attenuator circuit 51 is 0, the desired wave signal which is input from the antenna is input into the RF amplification circuit 53 without being attenuated, is amplified at a predetermined resonance frequency by the RF amplifier 53, and the result is output to the next signal processing circuit which is not shown in the drawings.

[0042] Furthermore, when the field strength of the desired wave which is input from the antenna is strong, if the impedance of the AGC signal is reduced by the control circuit, first, the gain of the transistor Q1 is reduced by the base current which is input into the transistor Q1 in the RF amplification circuit 53 being reduced by the resistors R1, R2 in the current control circuit 52.

[0043] Moreover, if the impedance of the AGC signal is further reduced by the control circuit and the potential on the resistor R1 side of the current control circuit 52 exceeds the on voltage of the diode D1, the diode D1 is turned on, the variable attenuation function of the attenuator circuit 51 is activated, the desired wave signal which is input from the antenna is attenuated, and the result is input to the base of the transistor Q1 in the RF amplification circuit 53.

[0044] In the RF amplification circuit 53, the signal is amplified using a predetermined resonance frequency by the LC resonance circuit and the transistor Q1 with a reduced gain, and the result is output to a later signal processing circuit which is not shown in the drawings.

[0045] Thus, with the automatic gain control circuit 50 according to the second embodiment, when the field strength of the desired wave is weak, attenuation by the attenuator circuit 51 and gain reduction by the current control circuit 52 are not carried out, and when the field strength of the desired wave is strong, first the gain of the transistor Q1 in the RF amplification circuit 53 is reduced by the current control circuit 52 in accordance with the reduction in the impedance of the AGC signal, and then the desired wave signal is attenuated by variable and attenuation operation by the attenuator circuit 51 and the result is input into the RF amplification circuit 53.

[0046] Accordingly, by applying the automatic gain control circuit 50 according to the second embodiment to a radio receiver, current automatic gain control and attenuation automatic gain control functionality can be provided, and by switching between the two types of gain control, the desired wave signal required by the radio receiver can be amplified with a low current and in a broad dynamic range, thereby making it possible to improve the intermodulation characteristics of the reception unit in a pager, etc., as a mobile radio receiver.

[0047] Note that the variable attenuation operation in the present embodiment depends on the voltage on the resistor R1 side in the current control circuit 52, and therefore it is possible to vary the point at which the current automatic gain control and the attenuation automatic gain control are switched between by changing the resistance ratios of the resistor R1 and the resistor R2 in the current control circuit 52.

[0048] FIG. 4 is a circuit configuration diagram of an automatic gain control circuits 60 configured by replacing the transistor Q1 in the RF amplification circuit 53 in FIG. 3 with a dual gate FET (field effect transistor) Q1. In FIG. 4, the automatic gain control circuit 60 is configured by an attenuator circuit 61 which is configured by a capacitor C1 and a diode D1, a current control circuit 62 which is configured by resistors R1, R3 and resistors R4, R5, and RF amplification circuit 63 which configured by the FET Q1 and an LC resonance circuit, bypass capacitors C2-C4, a coupling capacitor C5, and resistors R2, R6.

[0049] The functions and operation of the attenuator circuit 61, the current control circuit 62, and the RF amplification circuit 63 in this FIG. 4 are the same as those of the attenuator circuit 51, the current control circuit 52, and the RF amplification circuit 53 in the automatic gain control circuit 50 shown in FIG. 3, and descriptions thereof are omitted.

[0050] Accordingly, in this case, when the dual gate FET Q1 in the RF amplification circuit 63 is used as an amplifier, the gain can be controlled by controlling the voltage of the second gate using the attenuator circuit 61 and the current control circuit 62. Furthermore, in FIG. 4, a voltage divided by the resistors are four, are five is used as the bias voltage for the first and second gates of the

dual gate FET Q1, and therefore it is also possible to set the bias voltage by setting separate divided voltage resistances for each.

[0051] (Third embodiment) FIG. 5 to FIG. 7 are views showing a third embodiment of a pager to which an automatic gain control circuit according to the present invention is applied. First, a configuration is described. FIG. 5 is a circuit configuration diagram of a reception unit 70 of a pager according to the third embodiment. In this diagram, the reception unit 70 is configured by an antenna 71, and AGC circuit 72, a front end circuit 73, and RF amplification circuit 74, a mixer circuit 75, a first local unit 76, a bias variation circuit 77, an IF unit 78, a detection IC unit 79, a data conversion circuit unit 80, and a control unit 81.

[0052] When the desired wave received by the antenna 71 has a strong field, the AGC circuit 72 attenuates the desired wave signal by a predetermined amount, reduces the current supplied to the front end circuit 73, and improves the strong field intermodulation characteristics. The gain is adjusted by the bias current supplied to the base of the transistor Q1 being varied by the bias variation circuit 77, and the front end circuit 73 uses this gain to amplify the desired wave circuit which is input from the AGC circuit 72, and outputs the result to the RF amplification circuit 74.

[0053] The RF amplification circuit 74 amplifies the desired wave signal which is input from the front end circuit 73 at a predetermined amplification ratio and outputs the result to the mixer circuit 75. The mixer circuit 75 uses the current signal which is input from the first local unit 76 to reduce the frequency of the desired wave signal which is input from the RF amplification circuit 74 and outputs the current signal to the IF unit 78. Furthermore, with the mixer circuit 75, the bias current supplied to the base of the transistor Q2 by the bias variation circuit 77 is varied, thereby improving the linearity during medium field intermodulation.

[0054] The first local unit 76 outputs to the mixer circuit 75 a local signal in which the frequency of the desired wave signal which is input into the mixer circuit 75 is reduced. The bias variation circuit 77 turns the FET on and off using a bias control signal which is input from the control unit 81, thereby varying the bias current which is supplied to the base of the transistor Q2 in the mixer circuit 75 and the bias current supplied to the base of the transistor Q1 in the front end circuit 73.

[0055] The bias variation circuit 77 specifically has functionality whereby the bias current of the front end circuit 73 is reduced during medium field intermodulation and the bias current of the mixer circuit 75 is increased, thereby improving medium field intermodulation characteristics. The IF unit 78 amplifies the current signal which is input from the mixer circuit 75 at a predetermined amplification ratio and outputs the result to the detection IC unit 79.

[0056] The detection IC unit 79 removes the carrier wave component from the amplified current signal which is input from the IF unit 78, extracts the demodulated signal, and outputs the detection signal to the control unit 81. The data conversion circuit unit 80 is configured by an A/D converter, and converts the RSSi signal indicating the field strength which is input from the detection IC unit 79 into a digital signal, and outputs this digital signal to the control unit 81.

[0057] The control unit 81 detects the field strength of the desired wave using the digital signal which is input from the digital conversion circuit unit 80, outputs a bias control signal to the bias variation circuit 77 if the detection result indicates a medium field, and turns the FET inside the bias variation circuit 77 on and off. Thus, the reception unit 70 converts the RSSi signal which is output by the detection IC unit 79 into a digital signal using the data conversion circuit unit 80, and monitors the digital signal using the control unit 81 to determine the field strength. Therefore, power consumption in the pager 70 can be reduced.

[0058] Next, operation of the third embodiment is described. First, FIG. 6 shows operating conditions based on field strength in the AGC circuit 72 and the bias variation circuit 77. In FIG. 6, first if the field strength of the desired wave which is received from the antenna 71 is weak, the AGC circuit 72 is not activated, and the bias occurrence of the front end circuit 73 and the mixer circuit 75 are held in their normal state.

[0059] If the field strength is medium, the AGC circuit 72 is not activated, the bias current of the front end circuit 73 is reduced, and the bias current of the mixer circuit 75 is increased. If the field strength is strong, the AGC circuit 72 is activated to attenuate the desired wave signal by a predetermined amount, and the bias currents of the front end circuit 73 and the mixer circuit 75 are held in their normal state.

[0060] Next, operation of the reception unit 70 based on these operating conditions is described following the flowchart shown in FIG. 7. The control unit 81 checks the field strength of the desired wave using the digital signal which has been input from the data conversion circuit unit 80 (step S1), and determines whether or not the field strength is weak (step S2).

5 [0061] If it is determined that the field strength is weak, the AGC circuit 72 is not activated, and the desired wave signal received from the antenna 71 is output to the front end circuit 73 without attenuation, as shown in FIG. 6. Furthermore, if the field is weak, the FET is turned on in the bias variation circuit 77, and therefore the bias currents of the transistor Q1 in the front end circuit 73 and the transistor Q2 in the mixer circuit 75 are held in their normal state.

10 [0062] If it is not determined that the field strength is weak in step S2 in FIG. 7 and it is determined that the field strength of the desired wave is medium in step S3, as shown in FIG. 6, the AGC circuit 72 is not activated, a bias control signal is output to the bias variation circuit 77 from the control unit 81 in step S6, and the FET is turned on and off, thereby reducing the bias current of the transistor Q1 in the front end circuit 73, and increasing the bias current of the transistor Q2 in
15 the mixer circuit 75.

[0063] Next, in step S7 a determination is made as to whether or not there has been a change to the field strength, even if the desired wave signal is input during the following intermittent reception timing. If it is determined that there has been no change, the bias state is held in step S8, but if it is determined that there has been a change, the process returns to the field strength check in step S1.

20 [0064] Furthermore, if it has not been determined that the field strength is medium in step S3 and it has been determined that the field strength is strong in step S4, then, as shown in FIG. 6, the AGC circuit 72 is activated (step S5) and the desired wave signal which is received by the antenna 71 is attenuated by a predetermined amount and output to the front end circuit 73. If the field strength is strong, the FET is not turned on and off in the bias variation circuit 77, and therefore
25 the bias currents of the transistor Q1 in the front end circuit 73 and the transistor Q2 in the mixer circuit 75 are held in their normal state.

[0065] Thus, with the reception unit 70 according to the third embodiment, the RSSi signal which is output by the detection IC unit 79 is converted into a digital signal by the data conversion circuit unit 80, and the control unit 81 monitors the digital signal to determine the field strength. If it is determined that the field strength of the desired wave is medium, the bias current of the transistor Q1 in the front end circuit 73 is reduced by the bias variation circuit 77, and the bias current of the transistor Q2 in the mixer circuit 75 is increased. Therefore, the intermodulation characteristics for medium strength fields can be improved while reducing power consumption in the reception unit 70.

[0066] [Effects of the Invention] As described above, with the invention as in claim 1, when the signal strength of a reception signal is at or above a predetermined level, bias control is changed to attenuate the input level of the reception signal which is input into an amplification circuit, thereby making it possible to improve the intermodulation characteristics of a reception unit and simultaneously reduce power consumption.

[0067] With the invention as in claim 2, if the signal strength reception level [SIC] of the reception signal is at or above a predetermined level, the bias voltage level which is in effect at the predetermined level is held, reducing the adverse effects in timing of switching between bias control and input level control.

[Brief Description of the Drawings]

FIG. 1 Is a Circuit Block Diagram of a Reception Unit 40 in a pager to which an automatic gain control circuit according to the present invention is applied.

FIG. 2 is a diagram showing input/output characteristics of an interfering wave signal a desired wave signal amplified in an RF amplifier 22 and FIG. 1.

FIG. 3 is a diagram showing a circuit configuration of an automatic gain control circuit according to a second embodiment to which the present invention is applied.

FIG. 4 is a diagram showing a circuit configuration of an automatic gain control circuit 60 in a case in which the transistor Q1 of the RF amplification circuit 53 in FIG. 3 is replaced by a dual gate FET Q1.

FIG. 5 is a circuit configuration diagram of a reception unit 70 of a pager according to the third embodiment to which the automatic gain control circuit according to the present invention is applied.

FIG. 6 is a diagram showing operating conditions of an AGC circuit 72 and a bias variation circuit 77 in FIG. 5.

FIG. 7 is a flowchart of operations carried out in the reception unit 70 in FIG. 5.

FIG. 8 is a circuit block diagram of a reception unit of a pager to which a conventional automatic gain control circuit is applied.

FIG. 9 is a circuit block diagram of a reception unit of a pager to which another conventional automatic gain control circuit is applied.

FIG. 10 is a graph showing input/output characteristics of an interfering wave signal and a desired wave signal amplified in an RF amplifier 2 and FIG. 8.

[Explanation of the Reference Numerals]

	1, 21, 71	antenna
15	2, 22	RF amplifier (harmonic wave amplification circuit)
	3, 6, 23, 26	bandpass filter
	4, 24	mixer
	5, 25	local oscillator
	7, 27	IF amplifier (amplification circuit)
20	8, 28	detection circuit
	9	AGC circuit
	10	AGC amplifier
	11, 32, 320	attenuation unit
	29	signal strength detection unit (detection means)
25	30	CPU
	31	switching unit
	31a, 31b	contact

	31c	mobile piece
	41	bias control AGC circuit (bias control means)
	42	input attenuation AGC circuit (attenuating means)
	43	attenuation diode
5	50, 60	automatic gain control circuit
	51, 61	attenuator circuit
	52, 62	current control circuit
	70	reception unit
	72	AGC circuit
10	73	front end circuit
	74	RF amplification circuit
	75	mixer circuit
	76	first local unit
	77	bias variation circuit
15	78	IF unit
	79	detection IC unit
	80	data conversion circuit unit
	81	control unit
	La, Lb	power line
20	D, D1, D2	diode
	R, R1, R2, R3	resistor
	C, C1, C2, C3	capacitor
	L1, L2	coil

Claims

[Claim 1] An automatic gain control circuit provided with an amplification circuit which amplifies a reception signal and disposed inside a radio receiver which outputs to a later stage the reception signal which has been amplified by the amplification circuit, comprising

5 a bias control means for controlling a bias voltage level applied to the amplification circuit until the signal strength of the reception signal reaches a predetermined value, and

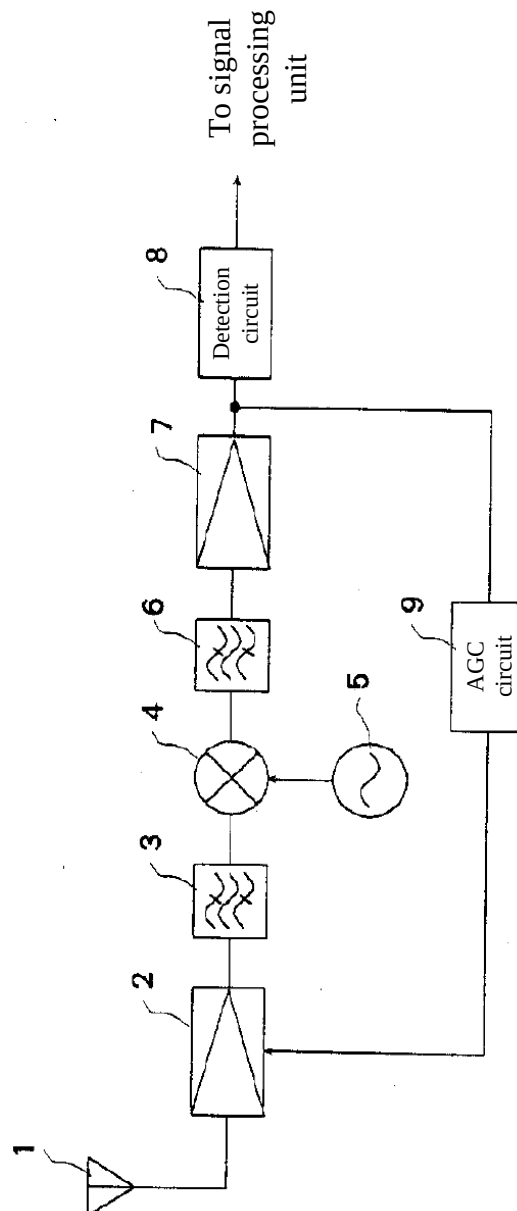
an attenuation means for attenuating the input level of the reception signal input into the amplification circuit once the signal strength of the reception signal has reached or exceeded the predetermined value.

10 [Claim 2] The automatic gain control circuit as claimed in claim 1, wherein, when the signal strength of the reception signal has reached or exceeded the predetermined value, the bias control means holds the bias voltage level which was in effect when the predetermined value was reached.

Abstract

[Problem] The present invention relates to automatic gain control circuits, and provides an automatic gain control circuit which improves intermodulation characteristics of an amplification circuit used in a radio receiver such as a pager, and minimizes power consumption in the radio receiver.

[Solution] A bias voltage which is output to an RF amplifier 22 by a bias control AGC circuit 41 is controlled until an excessive current signal is input, and when the excessive current signal is input into an input attenuation AGC circuit 42, an attenuation diode 43 is turned on by the bias voltage and a current signal which is input through an antenna 21 is split via the attenuating diode 43, thus attenuating the current signal which is input into the RF amplifier 22.



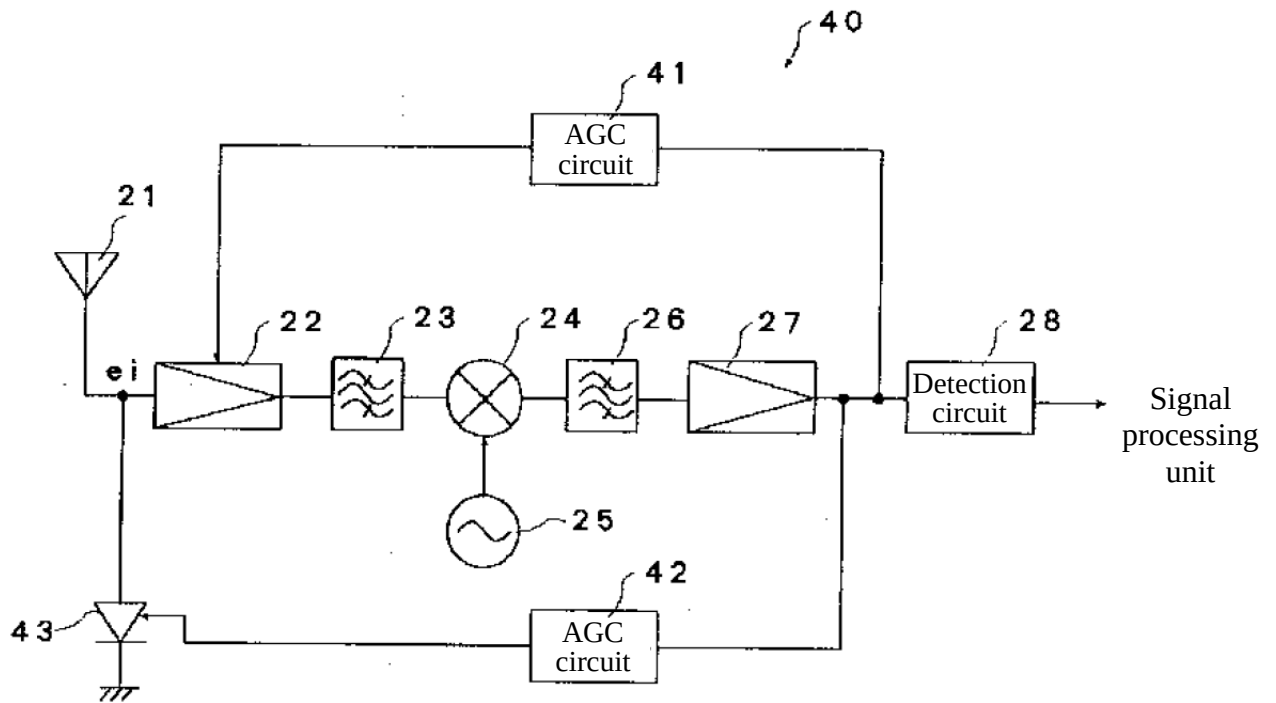


FIG. 1

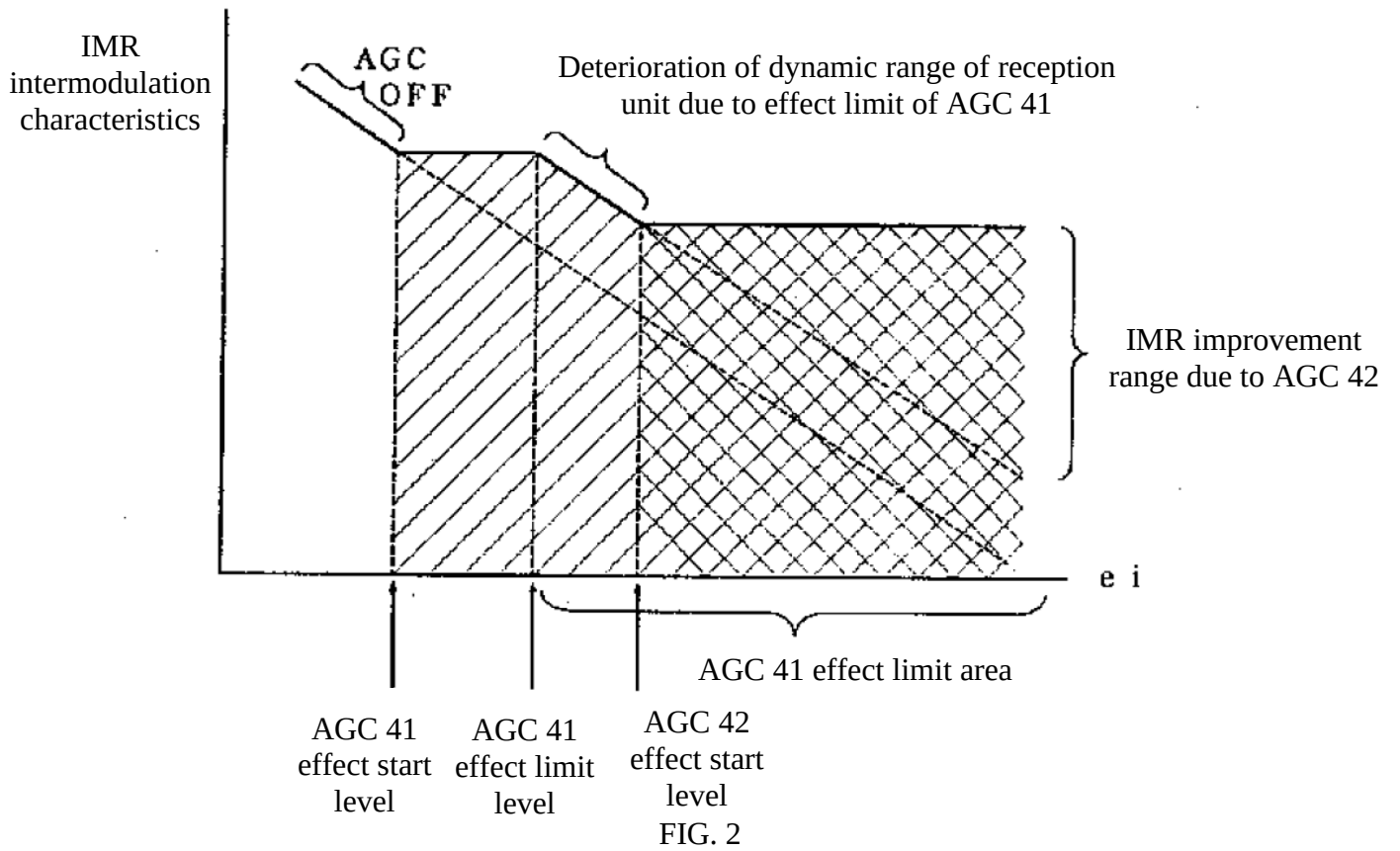


FIG. 2

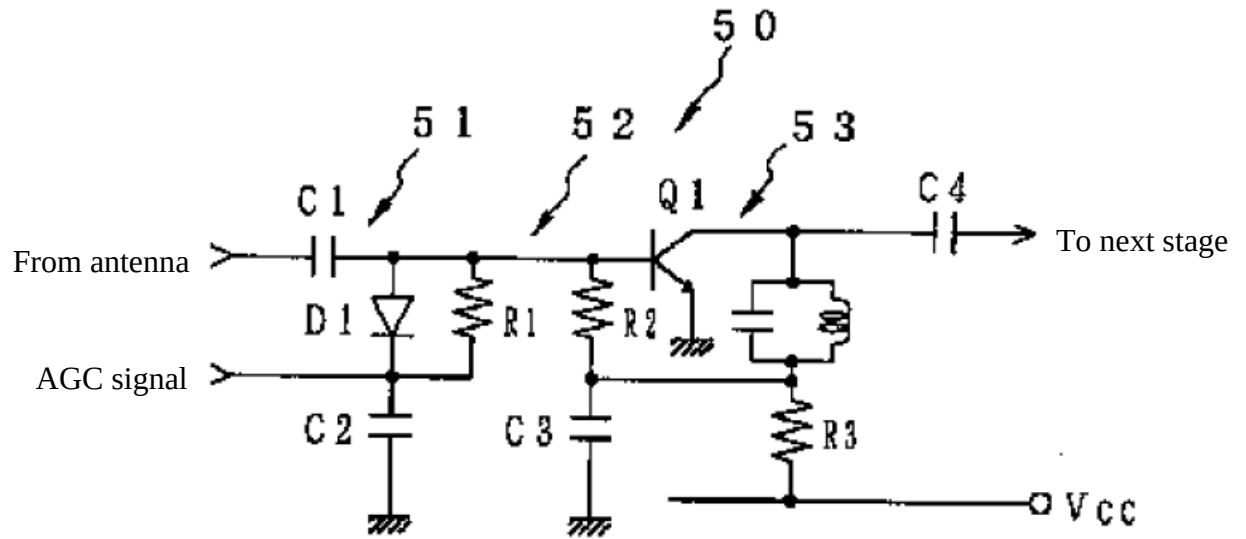


FIG. 3

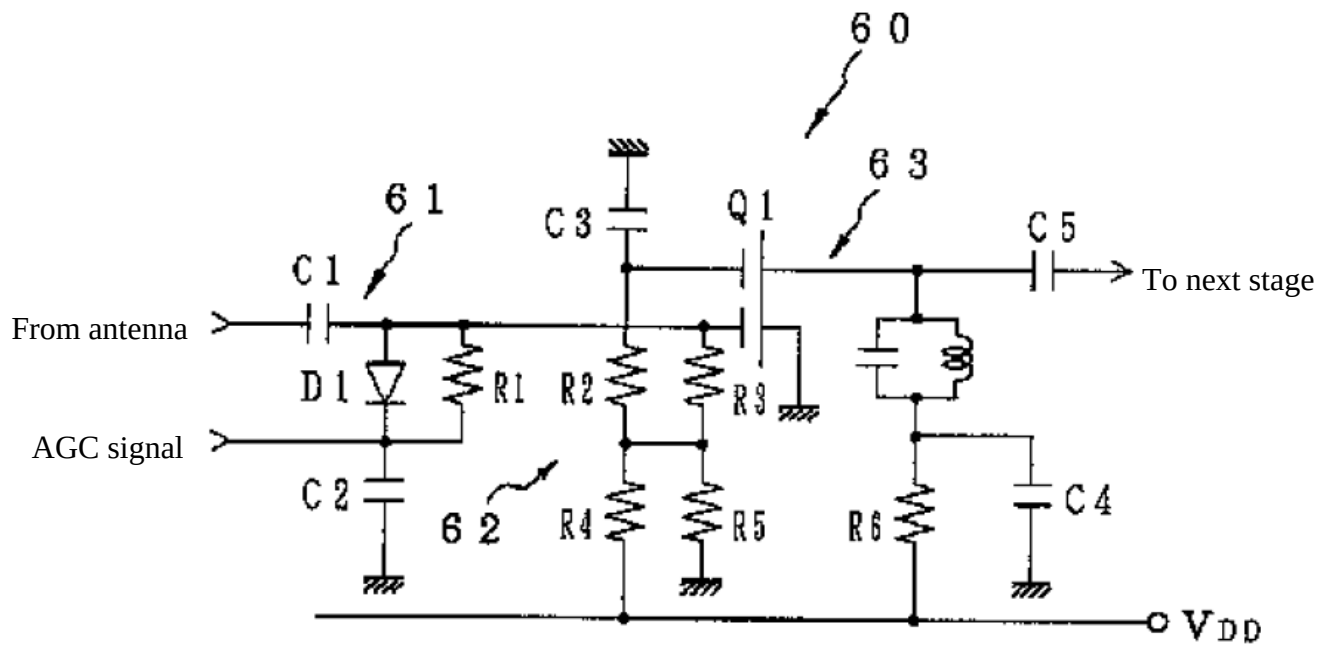


FIG. 4

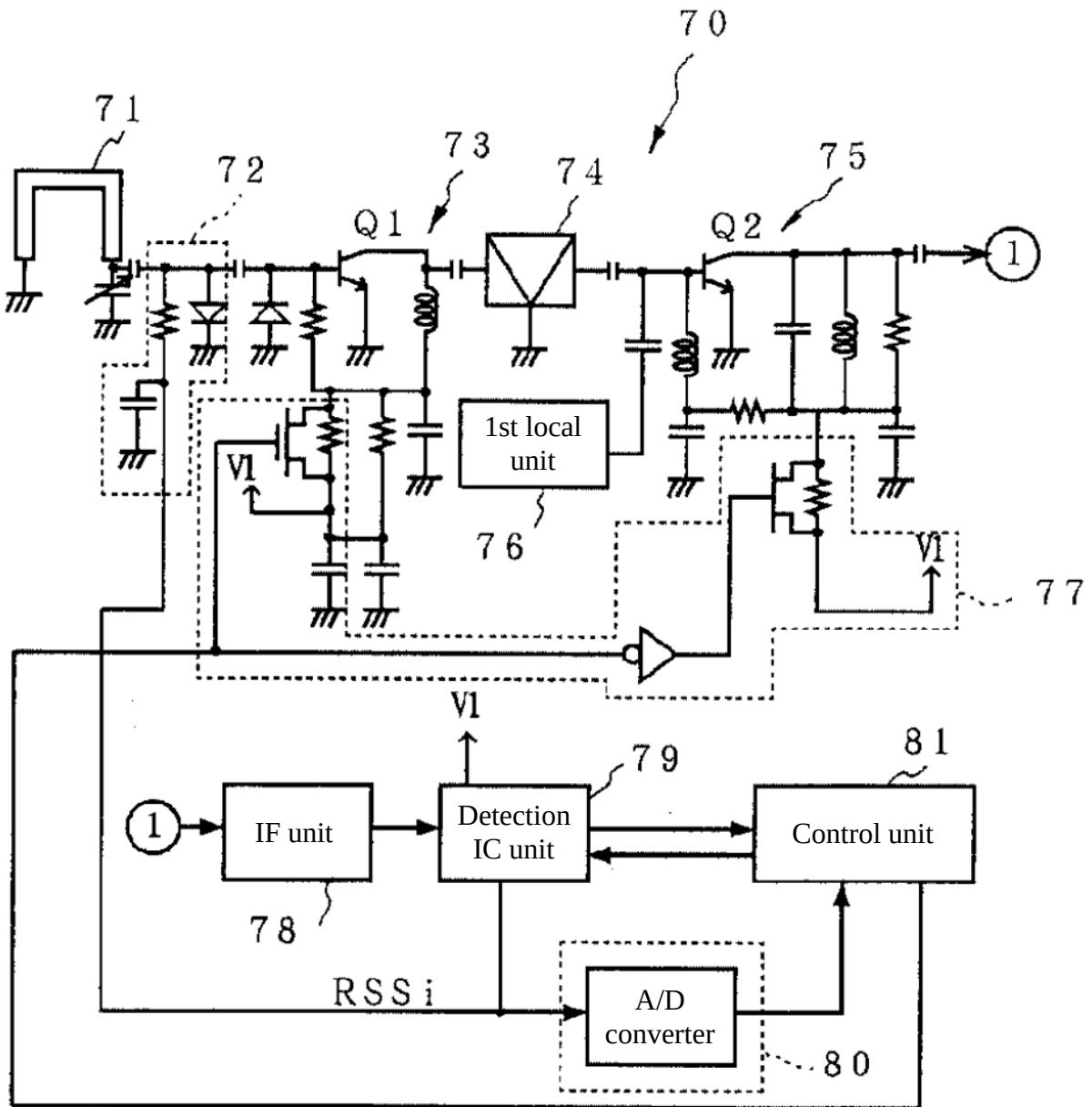


FIG. 5

Field state	AGC circuit	Front end bias	Mixer bias
Weak field	OFF	Normal	Normal
Medium field	OFF	Reduced	Increased
Weak field	ON	Normal	Normal

FIG. 6

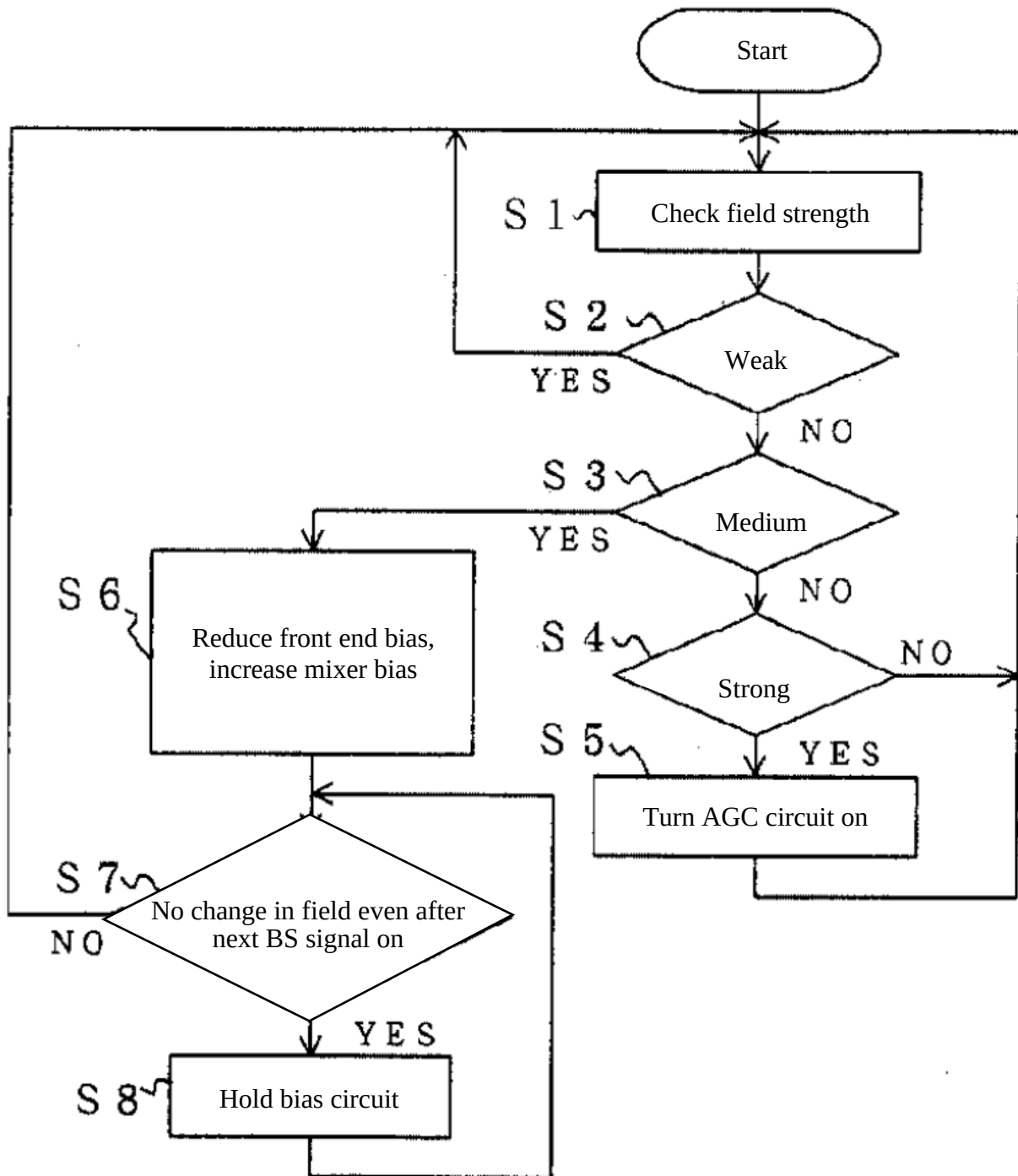


FIG. 7

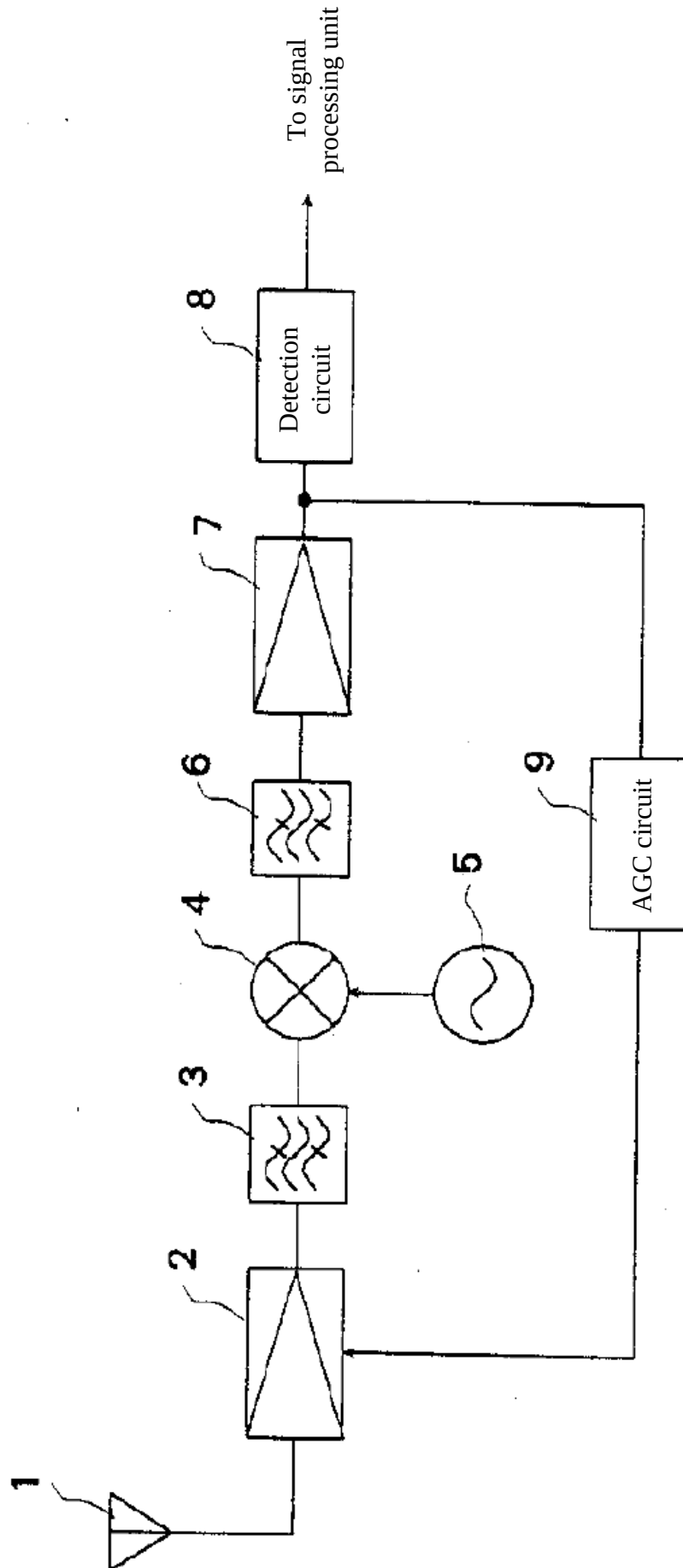


FIG. 8

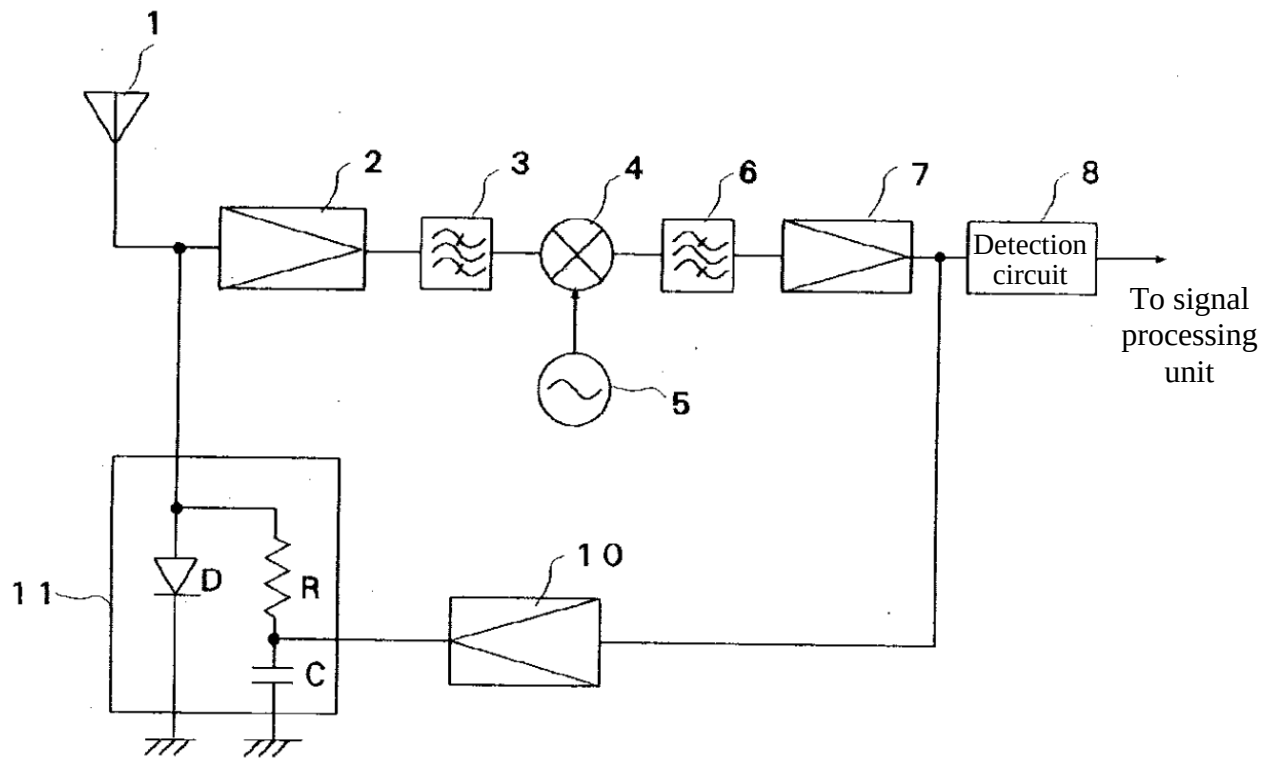
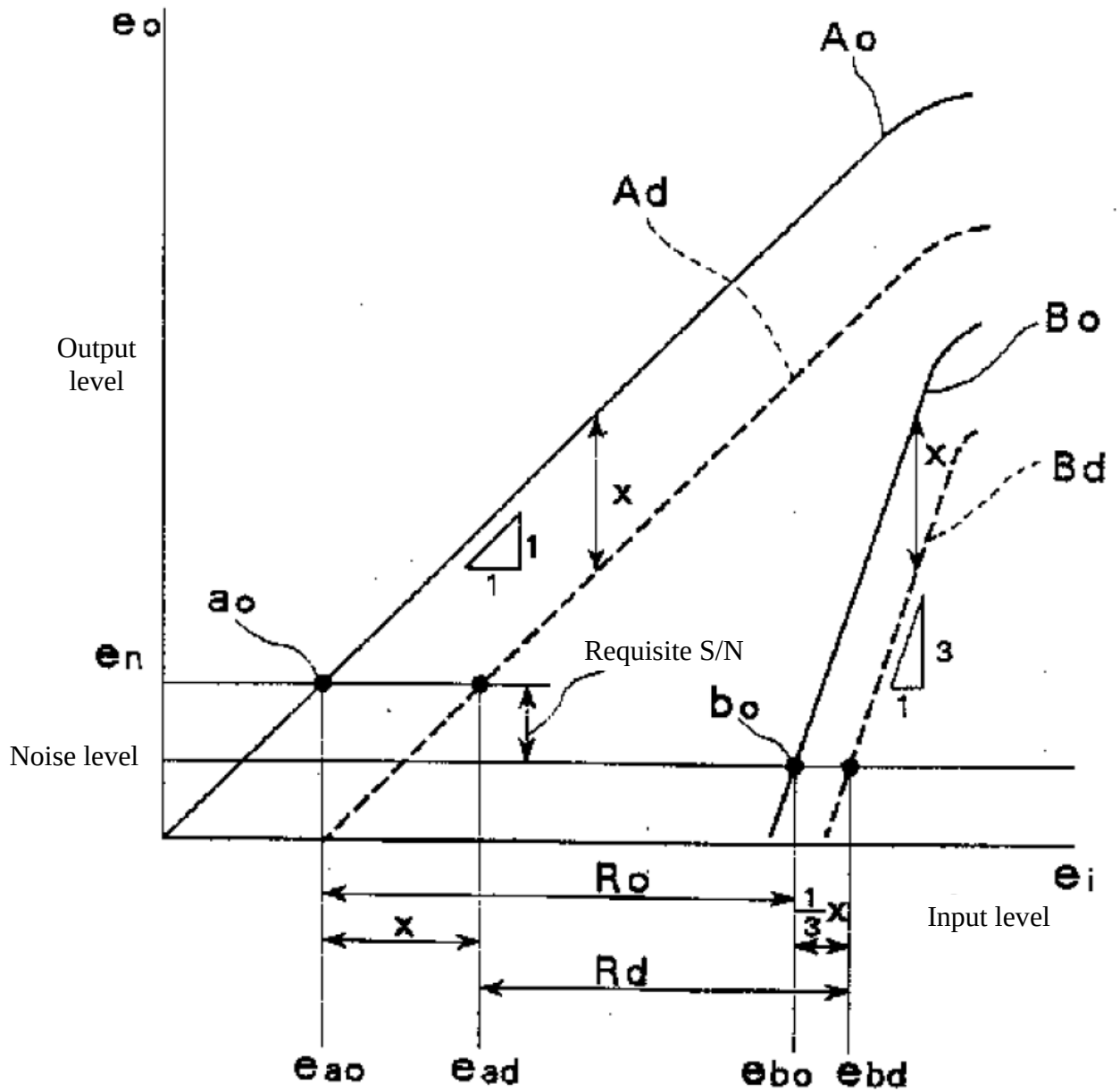


FIG. 9



A_o, A_d : input/output characteristic curve of desired wave signal
 B_o, B_d : input/output characteristic curve of interfering wave signal
 x : Gain reduction in RF amplifier 2
 R_o, R_d : dynamic range

FIG. 10