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(71) Applicant *(for all designated States except US)*: **MOTOROLA, INC.** [US/US]; 1303 E. Algonquin Road, Schaumburg, Illinois 60196 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **SALEM, Yaniv S.** [IL/IL]; Ha'Mekubalim 5, 46447 Hertzelia (IL). **AYUN, Moshe Ben** [IL/IL]; Hayasmin 27 P.O. Box 3026, 73142 Shoham (IL). **CHERMOSHNIUK, Oleg** [IL/IL]; Aharon Meskin 33/4 A, 84647 Be'er Sheva (IL). **MALKA, Haim** [IL/IL]; Moshe Dayan 7, 60401 Yehuda (IL).

(74) Agents: **DOUTRE, Barbara R.** et al.; 1303 East Algonquin RD, Schaumburg, Illinois 60196 (US).

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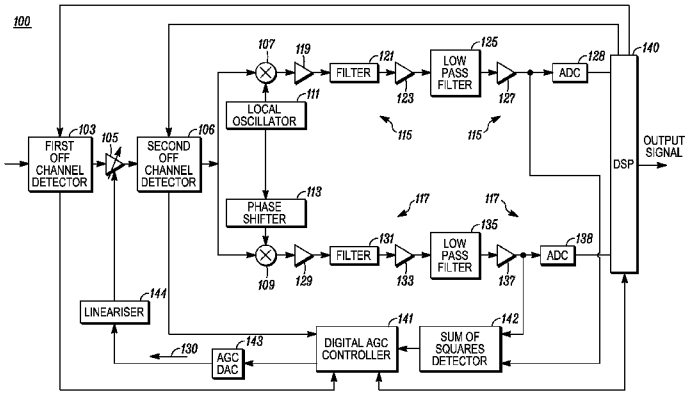


FIG. 1

(57) **Abstract**: An RF receiver (100) includes a variable gain device (105) for receiving an input RF signal, a mixer (107) for converting a signal produced by the variable gain device to a baseband signal, a baseband receiver channel (115) for processing the baseband signal, an AGC loop (130) coupled from the baseband channel to the variable gain device to provide AGC of the variable gain device, an AGC controller (141) to select an AGC threshold for use in the AGC loop, and an off-channel detector arrangement (103, 106) coupled to the AGC controller for detecting and indicating to the AGC controller: (i) a first condition when an off-channel signal has a level not less than a first detection threshold; and (ii) a second condition which during operation of the AGC loop is reached when an off-channel signal has been attenuated by the variable gain device to a level not greater than a second detection threshold, the AGC controller being operable upon receiving indication of the first condition to activate the AGC loop using a set AGC threshold and upon receiving indication of the second condition to dynamically adjust the AGC threshold to give a wanted level of a wanted on-channel signal.

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TITLE: RECEIVER AND METHOD OF OPERATION FOR USE IN MOBILE COMMUNICATIONS

TECHNICAL FIELD

The invention relates generally to a receiver and a method of operation of the receiver for use in mobile communications. In particular, the invention relates to a receiver suitable for receiving a wanted on-channel signal in the presence of a strong, unwanted off-channel signal.

BACKGROUND

A receiver designed for use in a narrow band mobile communication system may need to detect a wanted on-channel signal in the presence of a strong off-channel or interferer signal in a neighbouring channel, e.g. a channel having a frequency close to that of the wanted signal. Such a situation may occur for example where the wanted signal is a TETRA 1 signal and the unwanted signal is a TETRA 2 signal, or vice versa. A TETRA 1 signal is a signal sent in a system operating according to the basic TETRA standard defined by ETSI (the European Telecommunications Standards Institute). In that standard, there is a uniform spacing between RF channels of 25 kHz. A TETRA 2 signal is a signal sent in a system operating according to the more recent TETRA 2 or 'TEDS'('TETRA Enhanced Data Services') standard. That standard specifies a channel spacing selected from 25

KHz, 50 KHz, 100 KHz and 150 kHz depending on a required data communication rate. A TETRA 1 system and a TETRA 2 system may share a common spectrum. For example there may be a TETRA 1 channel having a channel width of 25 kHz channel and a channel centre frequency at 380.100 MHz and there may be a TETRA 2 (TEDS) channel having a channel width of 100 kHz and a channel centre frequency at 380.1625 MHz.

The closeness of the wanted on-channel signal and the unwanted off-channel can give rise to difficult problems in the design of the receiver, particularly relating to rejection of off-channel signals which might activate an AGC (automatic gain control) loop included in the receiver. In particular, receivers have to meet an 'ACR' or 'Adjacent Channel Rejection' specification. This specification defines the maximum RF level of an unwanted interfering signal in a channel adjacent to that of a wanted signal that can be applied at the receiver whilst still allowing the receiver to receive its wanted signal at a level which is 3 dB above sensitivity level.

Furthermore, receiver 'Desensitization' is an undesirable effect that occurs when a strong off-channel signal is present at the receiver together with a relatively weak on-channel signal, and the off-channel signal is strong enough to degrade the sensitivity of the receiver.

Several factors may contribute toward the condition of receiver Desensitization. The main examples are as follows:

(1) An amplitude modulated strong off-channel signal

may produce intermodulation products, especially second order intermodulation products. This problem is relevant mainly for direct conversion receivers in which a signal is converted in one stage directly from RF to baseband.

(2) A receiver front end LNA (low noise amplifier) may be driven into saturation at strong input signal levels causing the small signal (wanted) gain of the LNA to drop as the level of the off-channel signal becomes greater.

(3) Quadrature modulation phase noise may be increased.

The production of intermodulation products is a well known effect. For a constant IP (Intercept Point) system, when the strength of the interferer signal is raised by 1 dB, the strength of the wanted signal needs to be raised by 2 dB in order to preserve the same SNR (Signal to Noise Ratio).

For low on-channel signal levels, the off-channel signal level which causes the condition of Desensitization is about 80 dB higher than the on-channel signal level. However this difference decreases as the off-channel signal level increases since a stronger off-channel level produces stronger non-linear interference effects.

In prior art receivers, detection of the presence of a strong off-channel signal in the presence of a weaker on-channel signal is known. The usual way of dealing with the problem when such detection is made is to operate, via a closed loop control arrangement, one or more step attenuators at the receiver front end. Such operation

attenuates both the wanted on-channel signal and the unwanted off-channel signal. However, where the wanted signal is very weak, for example in signal fading conditions, the attenuation applied may degrade the receiver Noise Figure and Signal to Noise Ratio by an unacceptable amount. Thus, the level of the wanted on-channel signal at which the attenuation is applied needs to be selected carefully in order to maintain the wanted signal at a level which is a sufficiently greater than the receiver noise floor. This requirement conflicts with the need to apply as much attenuation as possible to the off-channel interferer signal in order to maintain good linearity of operation of the receiver front end, and thereby allow the receiver to be more immune to the problem of Desensitization.

Thus, there exists a need for a receiver which addresses at least some of the shortcomings of past and present receivers with regard to the problem of a strong off-channel interferer signal being present when the receiver is receiving an on-channel signal.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The accompanying drawings, in which like reference numerals refer to identical or functionally similar items throughout the separate views which, together with the detailed description below, are incorporated in and form part of this patent specification and serve to further illustrate various embodiments of concepts that include

the claimed invention, and to explain various principles and advantages of those embodiments.

In the accompanying drawings:

FIG. 1 is a block schematic diagram of an illustrative line up of part of a receiver embodying the invention.

FIG. 2 is a flow chart of a method of operation of the receiver of FIG. 1.

Skilled artisans will appreciate that items shown in the drawings are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the items may be exaggerated relative to other items to assist understanding of various embodiments. In addition, the description and drawings do not necessarily require the order illustrated. Apparatus and method components have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the various embodiments so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein. Thus, it will be appreciated that for simplicity and clarity of illustration, common and well-understood items that are useful or necessary in a commercially feasible embodiment may not be depicted in order to facilitate a less obstructed view of these various embodiments.

DETAILED DESCRIPTION

Referring now to the accompanying drawings, and in particular to FIG. 1, there is shown a block schematic diagram of part of a direct conversion receiver 100 embodying the invention. An input RF signal is first applied (in the part of the receiver 100 shown) to a first off-channel detector 103. The input signal may be an analog signal which has been picked up by an antenna (not shown) of the receiver 100 and delivered via an antenna switch or duplexer (not shown) and via one or more preliminary front end components such as one or more step attenuators (not shown) and one or more low noise amplifiers (not shown) to the first off-channel detector 103. An RF signal provided as an output by the first off-channel detector 103 is applied in turn to a variable gain device comprising an RF low noise amplifier 105 and a second off-channel detector 106. An RF signal provided as an output by the second off-channel detector 106 is applied to a mixer 107 and to a mixer 109. A reference RF signal equivalent to a carrier signal of the input RF signal is generated by a local oscillator 111 and is applied to the mixer 107. The reference RF signal generated by the local oscillator 111 is also applied to a phase shifter 113, which shifts the phase of the reference signal by ninety degrees, and the output of the phase shifter 113 is applied to the mixer 109. The mixer 107 downconverts the frequency of the input RF signal applied to it to produce a baseband I (in-phase) component of a modulation signal carried by the input RF signal. The I component is produced as an output signal by the mixer 107 and is processed in a first baseband

receiver channel, namely an I-channel 115. Similarly, a baseband Q (quadrature phase) component of the modulation signal carried by the input RF signal is produced as an output signal by the mixer 109 and is processed in a second baseband receiver channel, namely a Q-channel 117.

The I component produced by the mixer 107 is applied in turn in the I-channel 115 to a post mixer amplifier 119 having a low noise figure, a filter 121 which may be a one pole differential baseband filter, a baseband amplifier 123, a low pass filter 125 which may be a two pole baseband filter, a baseband amplifier 127 and an ADC (analogue to digital converter) 128 which may for example be a ΣΔ (sigma delta) ADC.

Similarly, the Q component produced by the mixer 109 is applied in turn in the Q-channel 117 to a post mixer amplifier 129 having a low noise figure, e.g. a filter 131 which is a one pole differential filter, a baseband amplifier 133, a low pass filter 135, e.g. which may be a two pole baseband filter, a baseband amplifier 137 and an ADC 138, e.g. a ΣΔ ADC.

Output signals from the ADC 128 and the ADC 138 are applied to a DSP (digital signal processor) 140 which performs additional known selectivity, demodulation and other signal processing operations, and provides an output signal which may be delivered via a suitable transducer (not shown), e.g. a high speed data output terminal or an audio output, to a user.

An AGC loop 130 extends from an input to the ADC 128 and an input of the ADC 138 to the low noise amplifier 105. The AGC loop 130 includes a sum of squares detector

142, a digital AGC controller 141, an AGC DAC (digital to analog converter) 143 and a lineariser 144. Signals in the channels 115 and 117 produced by the amplifiers 127 and 137 are sampled by the sum of squares detector 142 as well as being applied to the ADC 128 and the ADC 138. The sum of squares detector 142 operates in a known manner to produce a digital signal which represents the strength (sum of squares of amplitudes of the components) of the received baseband signal having the I and Q components delivered to the detector 142. The digital signal produced by the detector 142 is delivered to the digital AGC controller 141. The digital AGC controller 141 also receives control input signals from the off-channel detector 103 and the off-channel detector 106. The digital AGC controller 141 may also receive input signals from the DSP 140. The digital AGC controller 141 may be incorporated within the DSP 140 or may be separate from the DSP 140 as shown in FIG. 1.

The digital AGC controller 141 controls, using the input signals applied to it, operation of the AGC loop 130 in a manner described in more detail later. When the AGC loop 130 is activated, the digital AGC controller 141 provides a digital output signal to the AGC DAC 143. The AGC DAC 143 produces an analog output signal which is applied to the lineariser 144 which linearises the response of the low noise amplifier 105 in a known way. The lineariser 144 produces an output analog signal which is applied as an analog control signal to the low noise amplifier 105 to adjustably control the gain of the low noise amplifier 105. Thus, when the AGC loop 130 is

activated, the analog control signal applied to the low noise amplifier 105 is varied in a manner determined by the digital AGC controller 141, and the gain of the low noise amplifier 105 is adjusted to a desired value in response.

The digital AGC controller 141 may produce, in addition to the digital signal passed to the AGC DAC 143, a further output signal which is applied to control an attenuation level of a step attenuator (not shown).

A control loop (not shown) may be formed from the DSP 140 to the filters 121, 125, 131 and 135 to provide control signals needed to change a bandwidth of the filters 121, 125, 131 and 135 in a known manner according to the bandwidth of the channel of an input signal being received.

In use of the receiver 100, the baseband I component of the modulation signal carried by the received input RF signal is passed from the mixer 107 via the I-channel 115 to the ADC 128. It undergoes amplification by each of the amplifiers 119, 123 and 127 and filtering by the filter 121 and by the low pass filter 125 in a known manner. The filters 121 and 125 provide in combination some analog selectivity before the ADC 128. The filters 121 and 125 may have selectable bandwidths. Similarly, the baseband Q component of the modulation signal carried by the received input RF signal is passed from the mixer 109 via the Q-channel 117 to the ADC 138. It undergoes amplification by each of the amplifiers 129, 133 and 137 and filtering by the filter 131 and by the low pass filter 135 in a known manner. The filters 131 and 135

provide some analog bandwidth selectivity in the same manner as the filters 121 and 125.

The ADC 128 operates in a known manner. For example, the ADC 128 may quantise the incoming analog I component which it receives from the baseband amplifier 127, to form incremental samples. The ADC 128 may measure the value of each consecutive incremental sample and provide a digital output signal representing the I component in which the value of each successive incremental sample is indicated. The digital output signal provided by the ADC 128 is, as noted earlier, applied as an input signal to the DSP 140.

The ADC 138 may operate in the same manner as the ADC 128 to produce an output digital signal representing the Q component which is applied as another input to the DSP 140.

The AGC loop 130 controllably adjusts the gain of the low noise amplifier 105 in the manner described earlier to a value which will maintain the RMS signal level of the complex baseband signal comprising the I and Q components to a desired level below a saturation level of each of the ADC 128 and the ADC 138. The purpose of this adjustment is to avoid an undesirable condition of distortion of the baseband signal when saturation of the ADCs 128 and 138 is reached. When the condition of distortion occurs, there is a long time required for recovery from this condition.

The receiver 100 may measure the level (strength level) of the on-channel signal in a known way. For example, the DSP 140 may measure the level of the on-

channel baseband signal using the outputs of the ADCs 128 and 138 and an estimation of the current gain of the ADC loop 130 as reported to the DSP 140 by the controller 141 or by the amplifier 105. As seen in FIG. 1, the outputs of the ADCs 128 and 138 are provided after channel filtering in the I-channel 115 and the Q-channel 117. Such filtering removes most of the off-channel signals. The on-channel signal level measured in the DSP 140 is also known as the RSSI (received signal strength indication).

The on-channel signal levels measured in the manner described above are not precise because: (i) the channel filtering of off-channel signals is not absolute; and (ii) a slight inaccuracy may arise in the AGC gain data which is reported to the DSP 140.

The first off-channel detector 103 and the second off-channel detector 106 of the receiver 100 may operate in a known manner to estimate the off-channel signal level. Each may operate in one of the following ways.

Each of the detectors 103 and 106 may comprise a known broadband RF detector which provides an output voltage which is a measure of the strength of the RF signal applied to the detector. The signal applied consists of the on-channel signal and any off-channel signal present. The detector 103 may subtract from the measured level of the applied signal the level of the on-channel signal estimated by the DSP 140 as described above. The detector 106 may operate in a similar way, except that the on-channel signal level used in the subtraction is that after gain has been applied at the

amplifier 105. In each case, the detector gives an indication of whether the off-channel signal applied is above or below a certain level, namely the first threshold in the detector 103 and the second threshold in the detector 106. The first and second thresholds may be obtained by use of reference voltages which are programmable, e.g. by the DSP 140, thereby providing flexibility of detecting input signals at different levels. The reference voltages may be set at levels which take into account the estimated level of the on-channel signal.

Alternatively, a known power meter circuit may be employed to measure the power level of the applied signals. The circuit may include its own filtering effectively to remove the on-channel signal leaving only the off-channel signal(s). A power meter circuit is more accurate but is also more expensive than a broadband detector.

The receiver 100 may be operated in each of two modes to provide operation of the AGC loop 130. A first mode may be employed under normal conditions when the only signal detected is essentially the wanted on-channel signal. A second mode may be employed when there is a strong unwanted off-channel signal present.

In the first mode, the AGC threshold may be dynamically adjusted by the digital AGC controller 141 to be at a level which is a pre-determined difference below a monitored level of the PAR (peak to average ratio) of the baseband signal. The PAR may be measured in a known manner by the DSP 140. Activation of AGC operation by the

loop 130 may be triggered when the strength of the input signal reaches a relatively high level, e.g. -65 dBm.

In the second mode, the AGC operation of the loop 130 is triggered when the strength of the input signal reaches a relatively low level, e.g. -100 dBm, in order to maintain linear operation of the receiver 100. The AGC threshold selected by the digital AGC controller 141 in this case is a function of both the off-channel signal level and the on-channel signal level.

FIG. 2 is a flow chart of an illustrative method 200 embodying the invention. The method 200 illustrates operation of the receiver 100 to control the AGC loop 130 in the second mode of operation referred to above.

The method 200 begins in a step 201 in which the first off-channel detector 103 detects a first condition in which there is a strong off-channel signal (in the presence of a weaker, wanted on-channel signal) and, in response sends a control signal to the digital AGC controller 141. The detector 103 may operate using a first detection threshold which has been selected to indicate a threshold strength level of an off-channel signal being reached or exceeded.

In response to receiving the control signal sent in step 201, the digital AGC controller 141 sets the AGC threshold in a step 203 to a level which ensures sufficient SNR (Signal to Noise Ratio) for processing of the received wanted on-channel signal.

In response, the AGC loop 130 proceeds, as indicated in a step 205, to operate using the threshold as set in step 203. AGC operation as indicated by step 205

attenuates the on-channel and off-channel signals by the same amount.

As noted earlier, the amplifier 105 is a variable gain amplifier (VGA). The gain of this amplifier is controlled by the control signal produced by the digital AGC controller 141 and processed by the AGC DAC 143 and the lineariser 144. When the controller 141 decides that attenuation needs to be applied, the control signal delivered to the amplifier 105 reduces the gain of the amplifier 105. Thus, effectively attenuation is applied to the incoming signal.

As the attenuation applied occurs progressively, the second off-channel detector 106 continues to detect the off-channel signal, as indicated in step 209. The detector 106 may operate using a second detection threshold which has been selected to indicate that the off-channel signal, after it has passed through the low noise amplifier 105, has a strength level not less than the second threshold.

As long as the second off-channel detector 106 continues to detect the off-channel signal, no change is made to the AGC threshold by the digital AGC controller 141, as indicated by a step 211.

The progressive attenuation applied to the off-channel signal is such that eventually there is a second condition in which the second off-channel detector 106 no longer detects the off-channel signal. When the second condition occurs, as indicated by a step 213, a control signal is no longer sent by the second off-channel detector 106 to the digital AGC controller 141.

In response to receiving no longer a control signal from the second off-channel detector 106, but still receiving a control signal from the first off-channel detector 103 indicating that the first off-channel detector 103 is still detecting the off-channel signal, the digital AGC controller 141 dynamically adjusts the AGC threshold to a level which suits the wanted on-channel signal level in a step 215. The attenuation applied to the wanted on-channel signal is adjusted by dynamic adjustment of the AGC threshold so that the wanted signal level as processed by the I-channel 115 and the Q-channel 117 reaches a level giving a satisfactory SNR. The AGC threshold may be dynamically adjusted to be at a level equal to the AGC threshold set in step 203 less the wanted level of the on-channel signal.

Step 215 may be operated as follows. The DSP 140 may receive from the controller 141 or from the amplifier 105 a signal indicating the level of AGC being applied by the AGC loop 130. Thus, it is always known by the DSP 140 how much gain has been reduced by the AGC loop 130. This data is used by the DSP 140 (or is delivered by the DSP 140 to the controller 141 for use by the controller 141) when the second off-channel detector 106 detects the second condition in step 215. The DSP 140 (or the controller 141) uses the data to determine a level of the new AGC threshold to give a suitable level (a level suitably above the noise floor) of the wanted on-channel signal.

Illustrative non-limiting examples of the method 200 embodying the invention are as follows.

Example 1

At the antenna (not shown) of the receiver 100 the following signals are present:

(i) an off-channel interferer signal having a strength level of -10 dBm;

(ii) an on-channel wanted signal having a strength level of -90 dBm.

An AGC threshold required to avoid 'Desensitization' as described earlier is a signal strength level of -100 dBm.

The threshold level used in the first off-channel detector 103 is -20 dBm.

The threshold level used in the second off-channel detector 106 is -25 dBm.

Under these conditions, the AGC operation of the loop 130 will provide attenuation of both the off-channel signal and the on-channel signal by 10 dB.

Example 2

At the antenna (not shown) of the receiver 100 the following signals are present:

(i) an off-channel interferer signal having a strength level of -20 dBm;

(ii) an on-channel wanted signal having a strength level of -90 dBm.

The AGC threshold required to avoid 'Desensitization' as described earlier is a signal strength level of -100 dBm.

The threshold level used in the first off-channel detector 103 is -20 dBm.

The threshold level used in the second off-channel detector 106 is -25 dBm.

Under these conditions, when the AGC operation has attenuated both the off-channel interferer signal and the on-channel wanted signal by 5 dB the second off-channel detector 106 will no longer detect the off-channel signal, whilst the first off-channel detector 103 continues to detect the off-channel signal. At this point, the second condition referred to above, the AGC threshold is adjusted dynamically and will settle to a level of -95 dBm.

The receiver 100 and the method 200 of operation provide several benefits, including the following:

(1) The AGC threshold applied by the digital AGC controller 141 in the second mode may be adjusted as a function of the strength level of the on-channel signal as well as the strength level off-channel signal. This can ensure smooth transitions between signal strength levels during AGC operation giving no abrupt transients. The AGC threshold may be adjusted dynamically only when the AGC operation has attenuated the off-channel signal to a suitable level. Before that level is reached, the AGC threshold may be conveniently be kept substantially constant. Such operation ensures maintaining the wanted on-channel signal at an optimum level. Thus, in contrast to prior art arrangements in which incoming signals are attenuated essentially according to the level of the off-channel interferer signal level, the AGC operation is

carried out with reference also to the wanted on-channel signal level.

(2) Continuous AGC operation is provided when the AGC loop 130 is activated. In contrast to the prior art procedure of attenuating the input signal in steps using only a step attenuator, the amount of attenuation applied may be continuously varied, which gives an improvement in linearity of the receiver 100, especially in the presence of a strong off-channel interferer signal.

(3) The SNR of the receiver 100 may be automatically kept substantially constant with respect to the wanted on-channel signal. The SNR may for example be kept at a level of between about 25 dB and about 30 dB. Such a level is suitable for receipt of an on-channel signal in various reception conditions.

(4) The IIP2 (Input referred to the Second Order Intercept Point) of the receiver 100 may be improved in a continuous manner and may be optimized as a function of the strength level of the on-channel signal. This contrasts with the known use of step attenuators in which there are points of less than optimum performance during the attenuation steps. This benefit is obtained only where the receiver 100 is a direct conversion receiver. Continuous AGC operation, as in the method 200, may degrade the IP2 (second order intercept point) thereby degrading the linearity performance of the amplifier 105 owing to the production of second order intermodulation products. However in the direct conversion receiver 100, only the IP2 of the mixers 107 and 109 is important not

the IP2 of the amplifier 105. In consequence, the overall IP2 of the receiver 100 may be improved. The undesirable limitation of the IIP2 as obtained in the prior art is thereby largely avoided. This allows wider use of direct conversion receivers.

It is to be noted that the IP2 is an important parameter for direct conversion receivers. Firstly, an inferior IP2 produces unwanted intermodulation products in the same frequency band (baseband) as the wanted signal after down-conversion. (For dual conversion receivers, this effect is not a dominant effect.) Secondly, having a suitable IP2 becomes important for relatively high input off-channel interfering signals due to the high overall IIP2 of the direct conversion receiver. This effect is usually prevalent for off-channel interfering signals above about -25 dBm, although the precise signal strength at which it becomes significant depends on the particular receiver implementation.

(5) The IMR (Intermodulation Rejection Ratio) of the receiver 100 can be kept substantially constant throughout the continuous AGC operation range, particularly under strong interference conditions. This is beneficial for various modulations of the input signal, including linear modulation and constant envelope modulation.

For example, for some high performance receivers there is a requirement for an IMR of 80 dB. This requirement is usually for low on-channel signal levels (3 dB higher than the sensitivity specification) and an

off-channel interferer signal level of about -40 dBm. The requirement is achievable with a very linear receiver front end, without activating any AGC, but not with off-channel signal levels substantially above – 40 dB. Thus, it is desirable to try to improve the IMR performance for stronger off-channel signal levels. In the prior art this leads to the use of step attenuators which are not optimised for the exact on-channel and off-channel levels. However, the receiver 100 and method 200 provide operation of the AGC loop 130 in a manner which optimises SNR and linearity, thus optimising the IMR performance. For this to function properly, the AGC loop 130 needs to be highly linear, wherein the only factor which affects the receiver linearity is the front end gain of the receiver 100, especially in the low noise amplifier 105.

(6) The IP3 (Third Order Intercept Point) of the receiver 100 may be improved such that the IP3 of the amplifier 105 becomes the dominant contributor to the IP3 of the receiver 100. An inferior IP3 (like an inferior IP2) can produce unwanted non-linear intermodulation effects especially with strong off-channel signals present. Thus it is desirable to be able to design the receiver to be linear for high off-channel signal levels in which the IP3 (and IP2) is dominant. The receiver 100 beneficially allows such design.

CLAIMS

1. An RF receiver including a variable gain device for receiving an input RF signal, a mixer for converting an output signal produced by the variable gain device into a baseband signal, a baseband receiver channel for processing the baseband signal, an AGC (automatic gain control) loop coupled from the baseband receiver channel to the variable gain device to provide automatic gain control of the variable gain device, an AGC controller operable to select for use in the AGC loop an AGC threshold at which the AGC loop is activated, and an off-channel detector arrangement coupled to the AGC controller for detecting and indicating to the AGC controller: (i) a first condition when an off-channel signal has a strength not less than a first detection threshold; and (ii) a second condition in which during operation of the AGC loop an off-channel signal has been attenuated by the variable gain device to a level not greater than a second detection threshold, the AGC controller being operable upon receiving indication of the first condition to activate the AGC loop using a set AGC threshold and upon receiving indication of the second condition to dynamically adjust the AGC threshold to give a wanted level of an on-channel signal.

2. An RF receiver according to claim 1 wherein the variable gain device comprises a low noise amplifier.

3. An RF receiver according to claim 1 or claim 2 wherein the off-channel detector arrangement comprises a first detector operable to monitor a strength of an input signal prior to application of the input signal to the variable gain device, to subtract from the monitored strength a strength

level of a wanted on-channel signal and to give an output indicating the first condition.

4. An RF receiver according to claim 3 wherein the first detector is operable to compare the strength of the input signal with a first threshold and to produce an output signal when the strength of the input signal reaches the first threshold.

5. An RF receiver according to claim 3 wherein the off-channel detector arrangement comprises a second detector operable to monitor the strength of an input RF signal following application of the input RF signal to the variable gain device, to subtract from the monitored strength a strength level of a wanted on-channel signal and to give an output which indicates the second condition.

6. An RF receiver according to claim 4 wherein the second detector is operable to compare the strength of the input signal applied to it with a second threshold and to produce an output signal only when the strength of the applied input signal is not less than the second threshold.

7. An RF receiver according to any one of the preceding claims including in the baseband receiver channel an analog to digital converter, wherein the AGC loop is coupled to the receiver channel at an input of the analog to digital converter.

8. An RF receiver according to any one of the preceding claims including a first mixer for producing a baseband I (in-phase) component of the RF signal produced as an output signal by the variable gain device and a second

mixer for producing a baseband Q (quadrature phase) component of the RF signal produced as an output signal by the variable gain device, an I-channel operable to process the I component and a Q-channel operable to process the Q component, wherein the AGC controller is coupled to receive a sample of the I component from the I-channel and a sample of the Q component from the Q-channel.

9. A receiver according to any one of the preceding claims wherein the AGC controller is operable in a first mode in which no strong off-channel signal is detected and a second mode in which a strong off-channel signal is detected, wherein the AGC controller employs a threshold to trigger AGC operation in the first mode which is at a higher signal level than for a threshold to trigger AGC operation in the second mode.

10. A receiver according to any one of the preceding claims which is a direct conversion receiver.

11. A method of operation in an RF receiver including receiving an input signal by a variable gain device, converting an output signal produced by the variable gain device to a baseband signal by a mixer, processing the baseband signal by a baseband receiver, delivering a sample of the baseband signal to an AGC (automatic gain control) loop coupled between the baseband receiver channel and the variable gain device to provide automatic gain control of the variable gain device, and selecting by an AGC controller in the AGC loop an AGC threshold at which the AGC loop is activated, the method further including detecting by an off-channel detector

arrangement coupled to the AGC controller and indicating to the AGC controller: (i) a first condition when an off-channel signal has a strength not less than a first detection threshold; and (ii) a second condition which, during operation of the AGC loop, is reached when an off-channel signal has been attenuated by the variable gain device to a level not greater than a second detection threshold, the AGC controller upon receiving indication of the first condition activating the AGC loop using a set AGC threshold and upon receiving indication of the second condition dynamically adjusting the AGC threshold to give a wanted level of an on-channel signal.

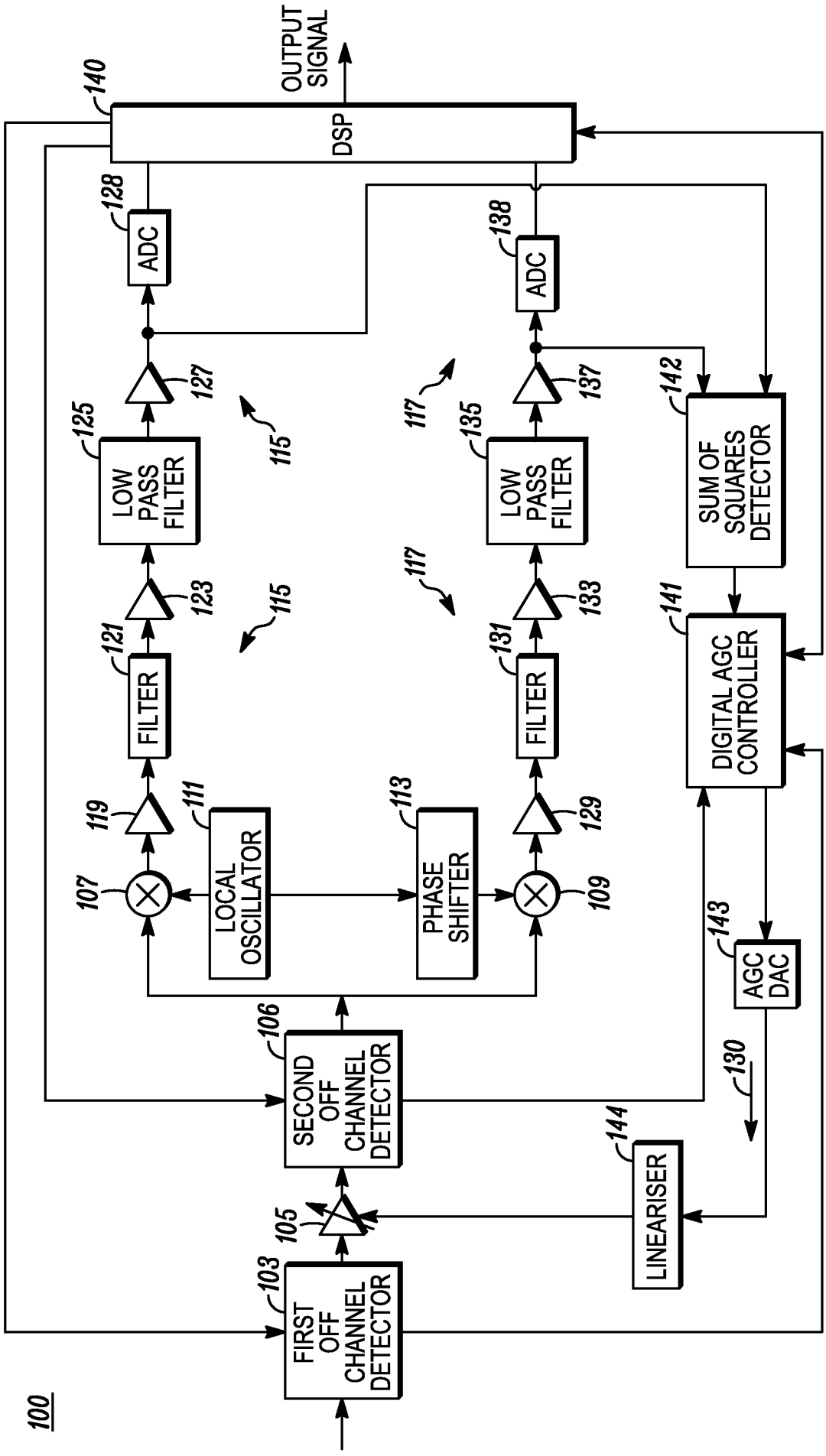

100
FIRST OFF CHANNEL DETECTOR
103
105
SECOND OFF CHANNEL DETECTOR
106
LINEARISER
144
130
AGC DAC
143
DIGITAL AGC CONTROLLER
141
SUM OF SQUARES DETECTOR
142
LOCAL OSCILLATOR
111
PHASE SHIFTER
113
107
109
115
117
119
121
123
125
127
129
131
133
135
137
FILTER
LOW PASS FILTER
ADC
138
128
DSP
140
OUTPUT SIGNAL

FIG. 1

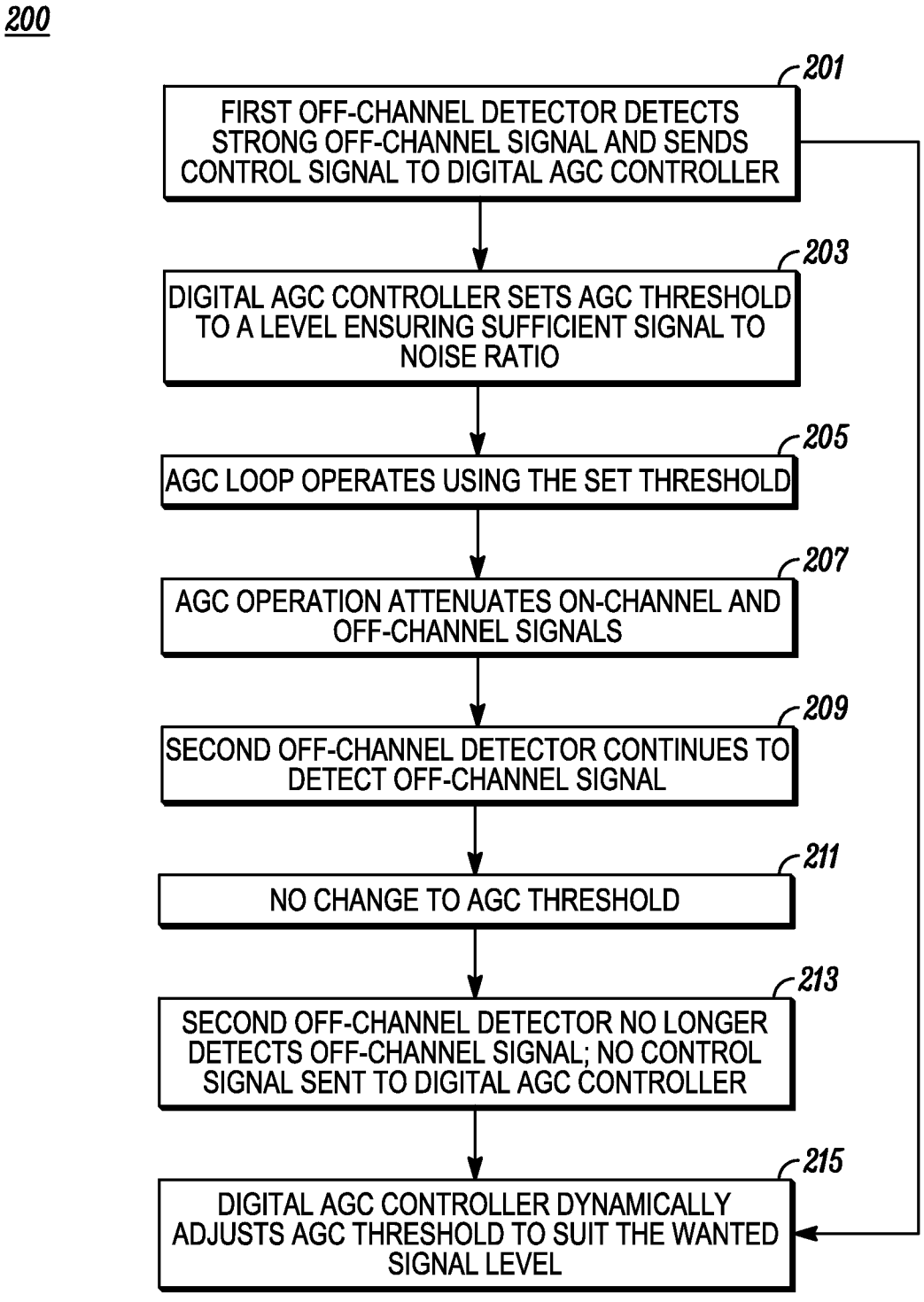

200
201
FIRST OFF-CHANNEL DETECTOR DETECTS STRONG OFF-CHANNEL SIGNAL AND SENDS CONTROL SIGNAL TO DIGITAL AGC CONTROLLER
203
DIGITAL AGC CONTROLLER SETS AGC THRESHOLD TO A LEVEL ENSURING SUFFICIENT SIGNAL TO NOISE RATIO
205
AGC LOOP OPERATES USING THE SET THRESHOLD
207
AGC OPERATION ATTENUATES ON-CHANNEL AND OFF-CHANNEL SIGNALS
209
SECOND OFF-CHANNEL DETECTOR CONTINUES TO DETECT OFF-CHANNEL SIGNAL
211
NO CHANGE TO AGC THRESHOLD
213
SECOND OFF-CHANNEL DETECTOR NO LONGER DETECTS OFF-CHANNEL SIGNAL; NO CONTROL SIGNAL SENT TO DIGITAL AGC CONTROLLER
215
DIGITAL AGC CONTROLLER DYNAMICALLY ADJUSTS AGC THRESHOLD TO SUIT THE WANTED SIGNAL LEVEL

FIG. 2