METHOD AND APPARATUS FOR INCREASING RECEIVER IMMUNITY TO INTERFERENCE

BACKGROUND OF THE INVENTION

I. FIELD OF THE INVENTION

The present invention relates to radio communications. More particularly, the present invention relates to improving a communication receiver's immunity to interference.

II. DESCRIPTION OF THE RELATED ART

There are presently multiple types of cellular radiotelephone systems operating. These systems include the advanced mobile phone system (AMPS) and the two digital cellular systems: time division multiple access (TDMA) and code division multiple access (CDMA). The digital cellular systems are being implemented to handle capacity problems that AMPS is experiencing.

All the cellular radiotelephone systems operate by having multiple antennas covering a geographic area. The antennas radiate into an area referred to in the art as a cell. The AMPS cells are separate and distinct from the CDMA cells. This makes it likely that the antenna for one system's cell may be located in a cell of another system. Likewise, within a particular system (AMPS, CDMA, and TDMA), there are two service providers within a given area. These providers often choose to place cells in different geographical locations from their competitor, hence there are situations where a radiotelephone on system 'A' might be far away from the nearest system 'A' cell while close to a system 'B' cell. This situation means that the desired receive signal will be weak in the presence of strong multi-tone interference.

This intermixing of system antennas can cause problems for a mobile radiotelephone that is registered in one system, such as the CDMA system, and travels near another system's antenna, such as an AMPS antenna. In this case, the signals from the AMPS antenna can interfere with the CDMA signals being received by the radiotelephone due to the proximity of the radiotelephone with the AMPS cell or the higher power of the AMPS forward link signal.

The multi-tone interference encountered by the radiotelephone from the AMPS signals creates distortion products or spurs. If these spurs fall

in the CDMA band used by the radiotelephone, they can degrade receiver and demodulator performance.

It is frequently the case in an AMPS system for the carriers (A and B bands) to 'jam' the competitor system unintentionally. The goal of the cellular carrier is to provide a high signal to noise ratio for all the users of their system by placing cells close to the ground, or near their users, and radiating the FCC power limit for each AMPS channel. Unfortunately, this technique provides for better signal quality for the carrier's system at the expense of interfering with the competitor's system.

Intermodulation distortion, such as that caused by the above situations, is defined in terms of the peak spurious level generated by two or more tones injected into a receiver. Most frequently, the third-order distortion level is defined for a receiver in terms of a third-order input intercept point or IIP3. IIP3 is defined as the input power (in the form of two tones) required to create third order distortion products equal to the input two tone power. As shown in FIG. 13, IIP3 can only be linearly extrapolated when a non-linear element, such as an amplifier, is below saturation.

As shown in FIG. 14, third-order distortion products occur when two tones are injected in a receiver. Tone #1 is at frequency f1 at power level P1 in dBm. Tone #2 is at frequency f2 at power level P2 in dBm. Typically P2 is set to equal P1. Third-order distortion products will be created at frequencies 2xf1 - f2 and 2xf2 - f1 at power levels P12 and P21 respectively. If P2 is set to equal P1, then spurious products should be equal, or P12 and P21 should be equal. Signal fc is injected at power level Pc to show that the added distortion is equal to a low level signal in this case. If there is a filter that filters out f1, f2 and f21 after the distortion is created, the power at f12 will still interfere with the signal power at fc. In example FIG. 14, for a CDMA application, the goal is that the intermod P12 should be equal to the signal power of -105 dBm for a total two tone power of -43 dBm, so the IIP3 must be > -9 dBm.

As is well known in the art, IIP3 for a single non-linear element is defined as the following:

$$IIP3 = \frac{IM3}{2} + P_{in}\ (dBm)$$

If $P_1 = P_2$, then $P_{in} = P_1 + 3$ dB or $P_2 + 3$ dB (dBm) and

$IM3 = P_1 - P_{12} = P_2 - P_{21} = P_2 - P_{12} = P_1 - P_{21}$ (dB)

For cascaded IIP3, where more non-linear elements are used, the equation is as follows:

$$IIP3 = -10*\log10[10^{(\text{Gain - element IIP3})/10} + 10^{(\text{-IIP3 of previous stages})/10}]$$

where: Gain = gain to element input.

Therefore, one way to improve the cascaded IIP3 of a receiver is to lower the gain before the first non-linear element. In this case, the LNA and mixer limit IIP3. However, another quantity needs to be defined that sets the sensitivity or lowest receive signal level without interference. This quantity is referred to in the art as the noise figure (NF). If the gain of the receiver is reduced to improve IIP3 (and interference immunity), the NF (and sensitivity to small desired signals) is degraded.

The Element NF is defined as the following:

$$\text{Element NF} = \frac{S_i}{N_i} - \frac{S_o}{N_o} \text{ (dB)},$$

where: $\frac{S_i}{N_i}$ is the input signal to noise ratio in dB, and

$\frac{S_o}{N_o}$ is the output signal to noise ratio in dB.

For elements in cascade in a receiver, the equation is as follows:

$$\text{Cascaded NF} = 10*\log10\left[10^{(NFi/10)} + \frac{10^{(NFe/10)} - 1}{10^{(Gain/10)}}\right],$$

where: NFe equals the noise figure of the element,

NFi equals the cascaded noise figure up to the element, and

Gain equals the running gain up to the element.

The 'best' cascaded NF can be achieved if the gain up to the element is maximized, this equation is in contradiction to the requirement for the 'best' cascaded IIP3. For a given element by element and receiver NF and IIP3, there are a limited set of gain values for each element that meet all of the requirements.

Typically, a receiver is designed with NF and IIP3 as predefined constants, as both of these quantities set the receiver's dynamic range of operation with and without interference. The gain, NF, & IIP3 of each device are optimized based on size, cost, thermal, quiescent and active element current consumption. In the case of a dual-mode CDMA/FM portable cellular receiver, the CDMA standard requires a 9 dB NF at minimum signal. In other words, for CDMA mode, the sensitivity

requirement is a 0 dB S/N ratio at -104 dBm. For FM mode, the requirement is a 4 dB S/N ratio at -116 dBm. In both cases, the requirements can be translated to a NF as follows:

$$NF = S\,(dBm) - \frac{S}{N}(dB) - N_{therm}\,(dBm/Hz) - \text{Signal BW}\,(dB/Hz),$$

where S is the minimum signal power,

$\frac{S}{N}$ is the minimum signal to noise ratio,

N_{therm} is the thermal noise floor (-174 dBm/Hz @ 290° K),

and Signal BW (dB/Hz) is the bandwidth of the signal.

Therefore,

CDMA NF = -104 dBm - 0 dB - (- 174 dBm/Hz) - 61 dB/Hz = 9 dB,

FM NF = -116 dBm - 4 dB - (- 174 dBm/Hz) - 45 dB/Hz = 9 dB,

where -61 dBm/Hz is the noise bandwidth for a CDMA channel

-45 dBm/Hz is the noise bandwidth for a FM channel

However, the receiver's NF is only required when the signal is near the minimum level and the IIP3 is only required in the presence of interference or strong CDMA signals.

There are only two ways to provide coverage in the areas where the carrier is creating strong interference. One solution is to employ the same technique; i.e., co-locate their cells along with the competition's. Another solution is to improve the immunity of a receiver to interference. One way to improve the immunity is to increase the receiver current. This is not a practical solution, however, for a portable radio that relies on battery power. Increasing the current would drain the battery more rapidly, thereby decreasing the talk and standby time of the radiotelephone. There is a resulting need to minimize multi-tone interference in a radiotelephone without impacting the current consumption.

SUMMARY OF THE INVENTION

The process of the present invention adjusts attenuation in a circuit, thereby improving a receiver's immunity to interference. The circuit has an attenuator with attenuation and automatic gain control (AGC) with a variable gain. The process varies the attenuation by a predetermined amount. The gain of the circuit is then detected. If the detected gain change is greater than a predetermined threshold, intermodulation

products have been detected and the front end attenuation is increased to reduce the intermodulation product power.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a block diagram of the apparatus of the present invention for increasing receiver immunity.

FIG. 2 shows a block diagram of another alternate embodiment of the present invention.

FIG. 3 shows a block diagram of another alternate embodiment of the present invention.

FIG. 4 shows a block diagram of another alternate embodiment of the present invention.

FIG. 5 shows a another plot of received RF input power versus carrier to noise ratio in accordance with the embodiment of FIG. 7.

FIG. 6 shows a plot of receive RF input power versus carrier to noise ratio in accordance with the embodiment of FIG. 8.

FIG. 7 shows a block diagram of another alternate embodiment of the present invention.

FIG. 8 shows a plot of interference power vs. signal power without using the apparatus of the present invention.

FIG. 9 shows a plot of interference power vs. signal power in accordance with the alternate embodiments of the apparatus of the present invention.

FIG. 10 shows a block diagram of an alternate embodiment of the present invention.

FIG. 11 shows a block diagram of another alternate embodiment of the present invention.

FIG. 12 shows a block diagram of another alternate embodiment of the present invention.

FIG. 13 shows a plot of non-linear transfer characteristics and distortion measurement.

FIG. 14 shows a spectral description of distortion products.

FIG. 15 shows a block diagram of a method for detecting the power of a received signal in accordance with the present invention.

FIG. 16 shows a flow chart of the attenuation control process of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

It is an objective of the present invention to vary the receiver NF and IIP3 for enhancing the IIP3 (or interference immunity) without compromising NF when necessary. This performance 'enhancement' is accomplished by varying the gain of the first active element in the receiver. The gain can be varied by varying the gain of the LNA over a continuous range or switching out the low noise amplifier with bypass switches.

A block diagram of the preferred embodiment of the present invention is illustrated in FIG. 1. This embodiment involves adjusting the LNA **115** gain on a continuous basis using adjustable gain control (AGC) **110** at the receiver front end. The continuous AGC **110** at thefront end also provides a linearity benefit at a minimum RF input level while the AGC **120** on the transmit side may reduce the IF AGC **125** and **130** requirements.

This embodiment detects the power output from the LNA **115**. The power detector **105** measures both the signal power and the jammer power together at RF. Using this embodiment, the power detector **105** can continuously decrease the LNA **115** gain at a lower received power than the -65 dBm of the subsequent "switched gain" embodiments of FIGs. 7, 10, 11 and 12.

The preferred embodiment operates by the power detector **105** detecting the received signal and jammer power at RF. This detected power goes through a loop filter and is used to adjust the receive AGC **110**, thereby adjusting the intercept point of the receive components. The gain is decreased as the measured power increases and the gain is increased as the measured power decreases. This embodiment could also combine the LNA **115** and the AGC **110** to form a variable gain LNA, thus eliminating the need for the separate AGC **110** block. The power of the transmit AGC **120**, located before the power amplifier **150**, is adjusted in the same way as the receive AGC **110** in order to maintain the overall TX power level.

AGC amplifiers **125** and **130** are also located after the mixers **135** and **140** in order to adjust the gain after the jammers have been filtered out by the bandpass filter **145**. These AGC amplifiers **125** and **130** perform the normal CDMA AGC function of open loop power control, closed loop power control, and compensation. These IF AGCs **125** and **130** are required due to the wide dynamic range requirements for CDMA. Typically, these

AGCs 125 and 130 have greater than 80 dB of gain range. The receive and transmit AGC 125 and 130 after the mixers are adjusted by another power detector 150 that measures the total power after the received signal is downconverted. The power detector 150 adjusts the AGCs 125 and 130 gain downward as the downconverted signal's power increases and adjusts the AGCs 125 and 130 gain upward as the downconverted signal's power decreases.

In the preferred embodiment, the received signals are in the frequency band of 869-894 MHz. The transmitted signals are in the frequency band of 824-849 MHz. Alternate embodiments use different frequencies.

The plot illustrated in FIG. 5 shows the benefit of this AGC approach. The left hand y-axis shows the carrier over noise ratio versus receive input power parameterized by the jammer level. The right hand y-axis shows the total jammer power required for a constant C/J as a function of received input power. When the jammer is not present (-100 dBm), the radio operates as though there is no RF AGC. As the jammer is increased, the C/N is decreased, but the effective linearity is also increased. In this example, the RF dynamic range is 30 dB and the threshold, where the RF AGC becomes active, is at the point the jammer power is greater than -25 dBm.

An alternate embodiment of the continuous gain adjustment is illustrated in FIG. 2. This embodiment first filters out the jammers with the bandpass filter 205 before the power detector 210 determines the power level of the downconverted signal. A threshold detector 225 determines when the signal power level reaches a certain point, -105 dBm in this embodiment, and then adjusts the AGCs 230 and 235 gain down when the signal power exceeds that power level. The AGCs 230 and 235 gain is adjusted upward when the signal power level goes below this threshold. The gain of AGCs 215 and 220 after the mixers 240 and 245 is adjusted continuously without checking for a predetermined threshold of power, performing the normal CDMA AGC power control.

The plot of this embodiment is illustrated in FIG. 6. When the threshold is set at -105 dBm, the minimum receive RF level, the C/N does not increase as quickly as the case where there is no RF AGC. The advantage of this embodiment is that the linearity benefit begins at a very low RF input power, no receive RF power detector is needed, and the AGC loop detects signal power only. Hence, the AGC loop is a simpler design than detecting at RF power.

Still another embodiment of the present invention is illustrated in FIG. 3. This embodiment operates similarly to the embodiment of FIG. 1. The only difference being the placement of the AGC **301** prior to the LNA **305** in the receive path.

Yet another embodiment of the present invention is illustrated in FIG. 4. This embodiment uses an attenuator **405** between the antenna **410** and the duplexer **415**. The attenuation is controlled by the power detector **420** after the LNA **425**. The power detector **420** measures the received signal and jammer power, filters it, and compares it to a predetermined threshold. In this embodiment, the threshold is -25 dBm. When the combined signal and jammer power reaches this threshold, the attenuation caused by the attenuator **405** is increased. This adjustment can be either in digital fixed steps or continuously adjusted. The AGC **430** and **435** after the mixers **440** and **445** are adjusted in the same manner as the FIG. 1 preferred embodiment.

An alternate embodiment of the apparatus of the present invention is illustrated in FIG. 7. This embodiment uses switches **701** and **702** to alter the front end gain. The actual switching level depends on the signal to noise requirements as a function of the signal level, or noise figure, for a particular CDMA radiotelephone design. The present invention can be used in an AMPS radiotelephone, however the switching characteristics will be changed to accommodate a different operating point.

This embodiment is comprised of an antenna **725** that receives and transmits radio signals. Receive and transmit paths in the radio are coupled to the antenna **725** through a duplexer **720** that separates the received signals from the transmitted signals.

A received signal is input to an LNA **703** that is coupled between two switches **701** and **702**. One switch **701** couples the LNA **703** to the duplexer **720** and the second switch **702** couples the LNA **703** to a band-pass filter **704**. In the preferred embodiment, the switches **701** and **702** are single-pole double-throw gallium arsenide switches.

The LNA **703** is coupled to one pole of each switch such that when both switches **701** and **702** are switched to those poles, the received signal is coupled to the LNA **703** and the amplified signal from the LNA **703** is output to the band-pass filter **704**. The band-pass filter **704** in this embodiment has a frequency band of 869-894 MHz. Alternate embodiments use different bands depending on the frequencies of the signals being received.

A bypass path 730 is coupled to the other pole of each switch. When the switches 701 and 702 are switched to their other poles, the received signal from the duplexer 720 bypasses the LNA 703 and is conducted directly to the band-pass filter 704. In this embodiment, these switches 701 and 702 are controlled by the radiotelephone's microcontroller 740. In an alternate embodiment, a separate controller is used to control the positions of these switches.

After the band-pass filter 704 has filtered the received signal, the filtered signal is downconverted to a lower intermediate frequency (IF) for use by the rest of the radio. The down-conversion is done by mixing 705 the received signal with another signal having a frequency set by a phase locked loop 707 driving a voltage controlled oscillator 706. This signal is amplified 750 before being input to the mixer 705.

The downconverted signal from the mixer 705 is input to the back end AGCs 708 and 709. These AGCs 708 and 709 are used by the radiotelephone for closed loop power control, as is already well known in the art.

In the process of the present invention, the microcontroller 740 monitors the power of the received signal. When the power exceeds -65 dBm, the microcontroller 740 instructs the switches 701 and 702 to switch to the bypass position, thus coupling the received signal directly to the bandpass filter 704. By bypassing the LNA 703 gain, the intercept point for the receiver is increased proportionally by the reduction in gain in dB. Alternate embodiments use other circuitry and methods to monitor the power of the received signal.

An alternate embodiment of the process of the present invention continuously adjusts the front end gain. This embodiment uses a lower power threshold such as -25 dBm.

The plots of FIGs. 8 and 9 illustrate the benefits of the switchable gain embodiments of the present invention illustrated in FIGs. 7, 10, 11 and 12. FIG. 8 illustrates a plot of interference power versus radio frequency (RF) signal power for a typical radio that is not using the switchable gain apparatus. This plot shows that the maximum interference level is limited to the receiver input compression point at -10.5 dBm. Both the single and dual tone power curves are shown.

The plot of FIG. 9 shows the interference power received by the radio versus the radio frequency signal power received by the radio using the switchable gain method and apparatus of the present invention. It can be seen that at the -65 dBm point of the graph, the switches are switched to

bypass the LNA gain thus allowing a greater interference power to be tolerated without affecting the RF signal power. Both the single tone and two tone power curves are shown.

Another alternate embodiment of the apparatus of the present invention is illustrated in FIG. 10. This embodiment uses a single-pole single-throw switch **1001**. In this embodiment, the switch **1001** is switched to the bypass path **1010** by the controller **1020** when the received signal power reaches -65 dBm. This effectively shorts out the LNA **1002** gain, thus coupling the received signal directly to the band-pass filter **1003**.

Yet another alternate embodiment of the apparatus of the present invention is illustrated in FIG. 11. This embodiment uses a single-pole single-throw switch **1105** that, when closed, shorts the input of the LNA **1110** to ground through a resistor **1101**. This creates an impedance mismatch at the input causing the signal to attenuate, thus reducing the gain caused by the LNA **1110**. As in the above embodiments, the switch **1105** is closed when the input signal power reaches -65 dBm. The resistance required for the resistor **1101** is dependent on the amount of attenuation desired. This resistance will be different for different LNA's in alternate embodiments.

Still another embodiment of the apparatus of the present invention is illustrated in FIG. 12. This embodiment uses a single-pole double-throw switch **1201** at the output of the LNA **1205**. The LNA **1205** is connected to one pole of the switch **1201** and a bypass path **1210** is connected to the other pole. The input to the bypass path **1210** is connected to the input of the LNA **1205**. When the power level of the received RF signal reaches -65 dBm, the switch **1201** is thrown from the position coupling the LNA **1205** to the band-pass filter **1220** to the bypass path **1210**. This couples the signal directly to the band-pass filter **1220**, bypassing the gain of the LNA **1205**.

In all of the above embodiments, the LNA can be powered down at the same time that it is bypassed by the switch or switches. This can be accomplished by connecting the LNA's power pin to a switch that is also controlled by the controller. Once the LNA is bypassed and is no longer used, power can be removed. This reduces the power consumption of the radio, thus increasing the talk and standby time for which the battery can be used.

In another embodiment of the present invention, E_c/I_o detection is used to determine when to adjust the front end gain. Additional embodiments use other quality measurements, such as E_b/I_o.

These ratios are quality measurements for digital communications system performance. The E_b/I_o ratio expresses the energy per bit to the total interference spectral density of the channel while the E_c/I_o ratio expresses the energy per CDMA chip relative to the total interference spectral density. E_b/I_o can be considered a metric that characterizes the performance of one communication system over another; the smaller the required E_b/I_o the more efficient is the system modulation and detection process for a given probability of error. Given that E_c/I_o and received signal strength are readily available, the microcontroller can detect the presence of strong interference as a drop in E_c/I_o while the AGC detector detects the increased interference. The microcontroller can lower the front end gain to improve interference immunity which would improve E_c/I_o and lower the distortion products falling within the signal bandwidth.

When the signal quality goes above the E_b/I_o or E_c/I_o threshold, the front end gain is reduced. The gain adjustment can be accomplished using either the continuous adjustment method or the amplifier switching method, both described above.

Still another embodiment, illustrated in FIG. 15, would be to detect the signal power at IF or baseband instead of the combination of the signal and jammer power at RF. This approach is simpler in that there is only one power detector and AGC control loop.

FIG. 15 illustrates a block diagram of the alternate method of detecting the power of the received signal. The signal is first downconverted to baseband frequency **1501**. This analog signal is then converted to a digital signal **1505** for further baseband processing including determining the received signal strength. The chip correlator **1510** determines the energy per chip with respect to the energy of all the non-coherent components. This information, along with the received signal strength indicator (RSSI) is used by the processor **1515** to determine the amount of gain adjustment for both the receive **1520** and transmit **1530** power.

Since the received signal power measurement includes both the signal and jammer power, the receive gain is increased only when both the signal level and the energy per chip drops. Since the RSSI is being changed, the transmit power must also be changed to compensate, thus enabling the open loop power control to operate properly. Thus, the processor adjusts the transmit gain whenever the receive gain is adjusted.

Other embodiments use erasures or signal power to control the variable gain AGC. Additional embodiments, instead of controlling both transmit and receive power, only control receiver power.

A process for controlling the gain of the above embodiments is illustrated in FIG. 16. This process is based on the relationship illustrated in the graph of FIG. 13. In FIG. 13, one can see that as the interference input power increases along the X axis, the intermodulation products (the lower curve) increase faster than the interference power. Therefore, X dB of attenuation applied at the input will result in a decrease of the IM3 intermodulation products by 3*X dB if interference is present at the receiver input.

Typically, intermodulation products don't fall into the IF section of the radio due to their low power. Intermodulation products outside of the IF section of the radio do not cause receiver performance problems. Thus, adjustment of the receiver gain is only necessary if the intermodulation products are of sufficient power to affect the IF signal.

Referring to FIG. 16, the process of the present invention first adjusts the input gain **1601**. In the preferred embodiment, this gain adjustment is 3 dB. However, other embodiments can use other values of gain adjustment, such as the range of 1 dB - 6 dB. The receiver processing is then used to measure the change in the power of the received signal **1605**. In the preferred embodiment, the automatic gain control processing detects the IF signal power change. It is understood that measurement of the change in received signal power may be accomplished at the RF or baseband stages of the receiver as well.

If the signal power changes by approximately 3 dB, the CDMA signal is greater than the noise floor and there are no intermodulation products that might cause problems. Additional gain adjustment is not needed in this case, but increasing the gain will improve receiver sensitivity. IF signal power changes of approximately (3 ± 0.5) dB are still considered to be 3 dB.

If the IF signal power changes by less than 3 dB **1610**, the CDMA signal is less than the noise floor or there are no intermodulation products that might cause problems. In this case, the AGC is only seeing a small CDMA signal and noise. Therefore, it is necessary to increase the receiver circuit gain **1615** and thus increase the sensitivity of the receiver.

If the IF signal power changes by more than 3 dB, the intermodulation products are causing enough of a problem that additional gain adjustment is necessary **1620**. In the preferred embodiment, if the

input gain was changed by 3 dB the intermodulation products will change by 9 dB when large interference is present. In this case, the average gain may be decreased by a small amount (e.g., 3 dB) until the process of the present invention determines that the intermodulation products are reduced to an acceptable level.

The process of the present invention can be used continuously, checking for intermodulation products at a low rate. This rate is ten times per second in the preferred embodiment. Other embodiments use the process once per frame cycle. Still other embodiments use the process at other rates, such as upon detection of a significant error on the forward link.

In summary, the method of the present invention enables a mobile radio to travel near antennas of different systems while increasing the radio's resistance to radio frequency interference from the other system. By decreasing the front end gain, the intercept point of the radio's receive circuitry increases so that the spurs from the other system's signals will not cause performance degradation of the receiver and demodulator.

I CLAIM:

CLAIMS

1. An apparatus to increase a radio receiver's immunity to radio frequency interference, the radio receiver receiving a signal, the apparatus comprising:

a first switch coupled to the received signal, the first switch having a first position and a second position, the second position being coupled to a bypass path;

an amplifier, coupled to the first position of the first switch, for amplifying the received signal;

a second switch having a first position and a second position, the first position coupled to the amplifier and the second position being coupled to the bypass path; and

a controller coupled to the first switch and the second switch, the controller switching the first and second switches to the second positions in response to the received signal exceeding a predetermined power level.

2. The apparatus of claim 1 wherein the predetermined power level is -65 dBm.

3. The apparatus of claim 1 wherein the amplifier is a low noise amplifier.

4. An apparatus to increase a radio receiver's immunity to radio frequency interference, the radio receiver receiving a signal, the apparatus comprising:

a switch coupled to the received signal, the switch having an open position and a closed position, the closed position being coupled to a bypass path;

a first amplifier having an input coupled to the first position of the switch and an output coupled to the bypass path; and

a controller coupled to the first switch, for switching the switch to the closed position in response to the received signal exceeding a predetermined power level.

5. The apparatus of claim 4 further comprising:

a filter coupled to the output of the first amplifier, the filter outputting a filtered received signal at a filter output;

an oscillator for generating an oscillator signal having a predetermined frequency;

a mixer, having a first input and a second input, the first input being coupled to the filter output and the second input being coupled to the oscillator, the mixer generating a downconverted signal in response to the oscillator signal and the filtered received signal;

a second amplifier coupled to the downconverted signal;

a third amplifier coupled to the downconverted signal;

a first surface acoustical wave filter, coupled to the second amplifier, for generating a signal for use in a digital radiotelephone system; and

a second surface acoustical wave filter, coupled to the third amplifier, for generating a signal for use in an analog radiotelephone system.

6. An apparatus to increase a radio receiver's immunity to radio frequency interference, the radio receiver receiving a signal, the apparatus comprising:

a switch coupled to the received signal, the switch having an open position and a closed position;

a resistance, a first end of the resistance being coupled to the closed position of the switch and a second end of the resistance being coupled to a ground potential;

an amplifier having an input coupled to the open position of the switch, for generating an amplified received signal at an output; and

a controller coupled to the switch, for switching the switch to the closed position in response to the received signal exceeding a predetermined power level.

7. An apparatus to increase a radio receiver's immunity to radio frequency interference, the radio receiver receiving a signal, the apparatus comprising:

an amplifier, having an input coupled to the received signal, for generating an amplified received signal at an output;

a bypass path coupled to the input of the amplifier;

a switch having a first position and a second position, the first position coupled to the amplifier output and the second position being coupled to the bypass path; and

a controller coupled to the switch, for switching the switch from the first position to the second position in response to the received signal exceeding a predetermined power level.

8. A method for increasing a radio receiver's immunity to radio frequency interference, the radio receiver having a receive amplifier and receiving a radio signal, the method comprising the steps of:

detecting a power level of the received radio signal; and

if the power level is equal to or greater than a predetermined threshold, decreasing the gain of the receive amplifier.

9. The method of claim 8 wherein the step of decreasing the gain of the receive amplifier includes bypassing the receive amplifier.

10. The method of claim 8 wherein the step of decreasing the gain of the receive amplifier includes generating an impedance mismatch between the received radio signal and the receive amplifier.

11. An apparatus to increase a radio receiver's immunity to radio frequency interference, the radio receiver receiving a signal, the apparatus comprising:

an amplifier coupled to the received signal for amplifying the received signal;

a receive automatic gain control having an input coupled to the amplified signal and an output;

a power detector coupled to the receive automatic gain control output, the power detector adjusting the receive automatic gain control in response to a detected power of the received signal.

12. An apparatus to increase a radio receiver's immunity to radio frequency interference, the radio receiver receiving a signal on an antenna, the apparatus comprising:

a duplexer for separating a transmit path from a receive path, the duplexer coupled to the antenna;

a receive amplifier, in the receive path, coupled to the duplexer for amplifying the received signal;

a receive automatic gain control, in the receive path, having an output and an input coupled to the amplified signal;

a transmit automatic gain control, in the transmit path, having an output and input coupled to a signal to be transmitted;

a transmit power amplifier, in the transmit path, having an input coupled to the output of the transmit automatic gain control and an output coupled to the duplexer; and

a power detector coupled to and adjusting the receive automatic gain control and the transmit automatic gain control in response to a detected power of the received signal.

13. An apparatus to increase a radio receiver's immunity to radio frequency interference, the radio receiver receiving a signal on an antenna, the apparatus comprising:

a duplexer for separating a transmit path from a receive path, the duplexer coupled to the antenna;

a variable gain receive amplifier, in the receive path, coupled to the duplexer for amplifying the received signal;

a variable gain transmit amplifier, in the transmit path, having an input coupled to a signal to be transmitted and an output coupled to the duplexer; and

a power detector coupled to and adjusting the variable gain receive amplifier and the variable gain transmit amplifier in response to a detected power of the received signal.

14. An apparatus to increase a radio receiver's immunity to radio frequency interference, the radio receiver receiving a signal on an antenna, the apparatus comprising:

a variable attenuator coupled to the antenna;

a duplexer for separating a transmit path from a receive path, the duplexer coupled to the variable attenuator;

a receive amplifier, in the receive path, coupled to the duplexer for amplifying the received signal;

a transmit amplifier, in the transmit path, having an input coupled to a signal to be transmitted and an output coupled to the duplexer; and

a power detector coupled to and adjusting the variable attenuator in response to a detected power of the received signal.

15. A circuit for increasing immunity of a radiotelephone to radio frequency interference, said radiotelephone having an antenna for receiving and transmitting radio signals and a duplexer coupled to said antenna, the circuit comprising:

a receive variable gain amplifier, coupled to said duplexer, for amplifying said received radio signals, said variable gain amplifier having a receive gain adjustment input and an output;

a receive power detector, having a gain adjust output coupled to said receive gain adjustment input and having an input, said receive power detector for detecting a power level of said received radio signals and adjusting a gain of said variable gain amplifier in response to said detected power level.

16. The circuit of claim 15 further comprising:

a downconverter, coupled to said receive variable gain amplifier output, for downconverting said received radio signals from a radio frequency to an intermediate frequency;

a receive intermediate frequency variable gain amplifier, having an input coupled to said downconverter and having an output, said receive intermediate frequency variable gain amplifier for amplifying said downconverted radio signals for use in said radiotelephone;

a transmit intermediate frequency variable gain amplifier, for amplifying an intermediate frequency signal to be transmitted, said transmit intermediate frequency variable gain amplifier having an output;

an upconverter, coupled to said output of said transmit intermediate frequency variable gain amplifier, for upconverting said signal to be transmitted from an intermediate frequency to a radio frequency; and

a transmit variable gain amplifier, having an output coupled to said duplexer, an input coupled to said upconverter, and a transmit gain adjustment input coupled to said receive power detector gain adjust output, said transmit variable gain amplifier for amplifying said upconverted signal to be transmitted, said transmit variable gain amplifier having a gain which is adjusted by said receive power detector in response to said detected power level.

17. The circuit of claim 16 wherein:

said receive power detector input is coupled to said receive intermediate frequency variable gain amplifier output, said receive power

detector detecting said power level of said received radio signals at said intermediate frequency; and

said circuit further comprises a threshold detector, having a threshold input coupled to said receive power detector gain adjust output and a threshold output coupled to said receive gain adjustment input and said transmit gain adjustment input, said threshold detector for adjusting said gain of said receive variable gain amplifier and said gain of said transmit variable gain amplifier when said detected power level exceeds a predetermined threshold.

18. The circuit of claim 16 wherein said receive power detector input is coupled to said receive variable gain amplifier output, said receive power detector detecting said power level of said received radio signals at said radio frequency.

19. The circuit of claim 17 further comprising a low-noise amplifier, coupled to said duplexer and said receive variable gain amplifier and interposed therebetween, for amplifying said received radio signals.

20. The circuit of claim 18 further comprising a low-noise amplifier, coupled to said duplexer and said receive variable gain amplifier and interposed therebetween, for amplifying said received radio signals.

21. The circuit of claim 18 further comprising a low-noise amplifier, coupled to said receive variable gain amplifier and said downconverter and interposed therebetween, for amplifying said received radio signals.

22. A receiver circuit for increasing immunity of a radiotelephone to radio frequency interference, said radiotelephone having an antenna for receiving and transmitting radio signals, a duplexer coupled to said antenna, and a signal processing circuit coupled to said duplexer, the receiver circuit comprising:

a receive amplifier, having an input and an output, said receive amplifier for amplifying said received radio signals;

a bypass path, switchably coupled to said receive amplifier, said bypass path for attenuating a gain of said receive amplifier when in a shunt position; and

a controller, coupled to said bypass path, for switching said bypass path to said shunt position when a detected power level of said received radio signals exceeds a predetermined threshold.

23. The receiver circuit of claim 22 wherein said bypass path comprises a first switch having an input coupled to said duplexer, and having a series position, a shunt position, and an output, said first switch output being coupled to said receive amplifier input when said first switch is in said series position and said first switch output being coupled to an input of a second switch when said first switch is in said shunt position, said second switch having an output coupled to said signal processing circuit, and having a series position and a shunt position, said second switch input being coupled to said receive amplifier output when said second switch is in said series position and said second switch input being coupled to said first switch output when said second switch is in said shunt position.

24. The circuit of claim 22 wherein said bypass path comprises a switch having an input coupled to said duplexer and having an output coupled to said receive amplifier output when said bypass path is in said shunt position.

25. The circuit of claim 22 wherein said bypass path comprises a switch having an output coupled to said signal processing circuit, and having an input coupled to said receive amplifier input when said bypass path is in said shunt position.

26. The circuit of claim 22 wherein said bypass path comprises a switchable load having an output coupled to a ground potential and having an input coupled to said receive amplifier input when said bypass path is in said shunt position.

27. A method for increasing immunity of a radiotelephone to radio frequency interference, said radiotelephone having an antenna for receiving radio signals having a received power level, an attenuator, a variable gain receive amplifier, a gain controller, and a receive power detector, the method comprising the steps of:

said gain controller varying said received power level of said received radio signals by a predetermined amount;

said receive power detector detecting a change in said received power level of said received radio signals; and

said gain controller adjusting a gain of said variable gain receive amplifier in response to said detected received power level change.

28. The method of claim 27 wherein said varying step comprises attenuating said received radio signals with said variable attenuator.

29. The method of claim 27 wherein said varying step comprises adjusting said gain of said variable gain receive amplifier.

30. The method of claim 28 wherein said adjusting step further comprises:

decreasing said gain of said variable gain receive amplifier when said detected received power level change is greater than a predetermined threshold; and

increasing said gain of said variable gain receive amplifier when said detected received power level change is less than or equal to a predetermined threshold.

31. The method of claim 29 wherein said adjusting step further comprises:

decreasing said gain of said variable gain receive amplifier when said detected received power level change is greater than a predetermined threshold; and

increasing said gain of said variable gain receive amplifier when said detected received power level change is less than or equal to a predetermined threshold.