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(54) **SIGNAL PROCESSING METHOD, PARTICULARLY IN A RADIO-FREQUENCY RECEIVER, AND SIGNAL CONDITIONING CIRCUIT**

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(30) **Foreign Application Priority Data**

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H04B 1/10 (2006.01)

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(58) **Field of Classification Search** 375/349, 375/316, 324, 340, 345
See application file for complete search history.

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(57) **ABSTRACT**

A first signal path having an amplifier and a second signal path having an amplifier with adjustable gain factor are provided. A signal applied to the first and second signal paths is amplified and demodulated on the first signal path. Concurrently, the signal is amplified on the second signal path with a gain factor, and a power of the signal amplified by the second signal path is determined and used for determining the gain factor. A signal conditioning circuit has first and second signal paths and a first and a second operating state. In the first operating state, the first signal path is arranged for amplification for a demodulation, and the second signal path is arranged for amplification for determination of a power of the signal present. In the second operating state, one of the two signal paths is inactive and the other is arranged for demodulating the signal present.

15 Claims, 2 Drawing Sheets

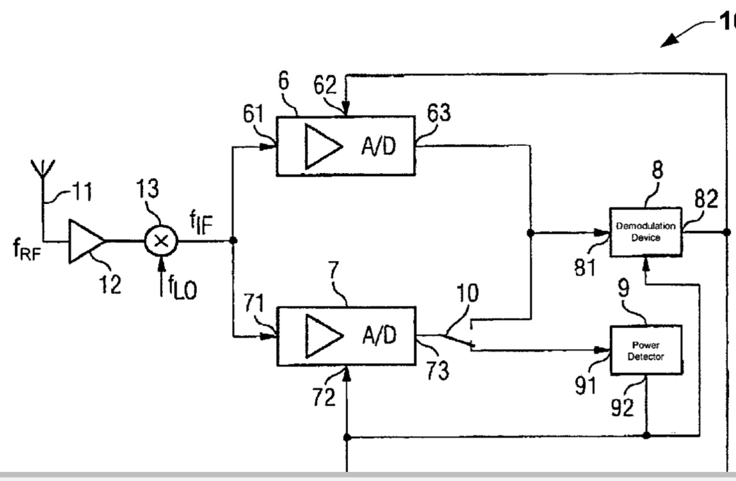
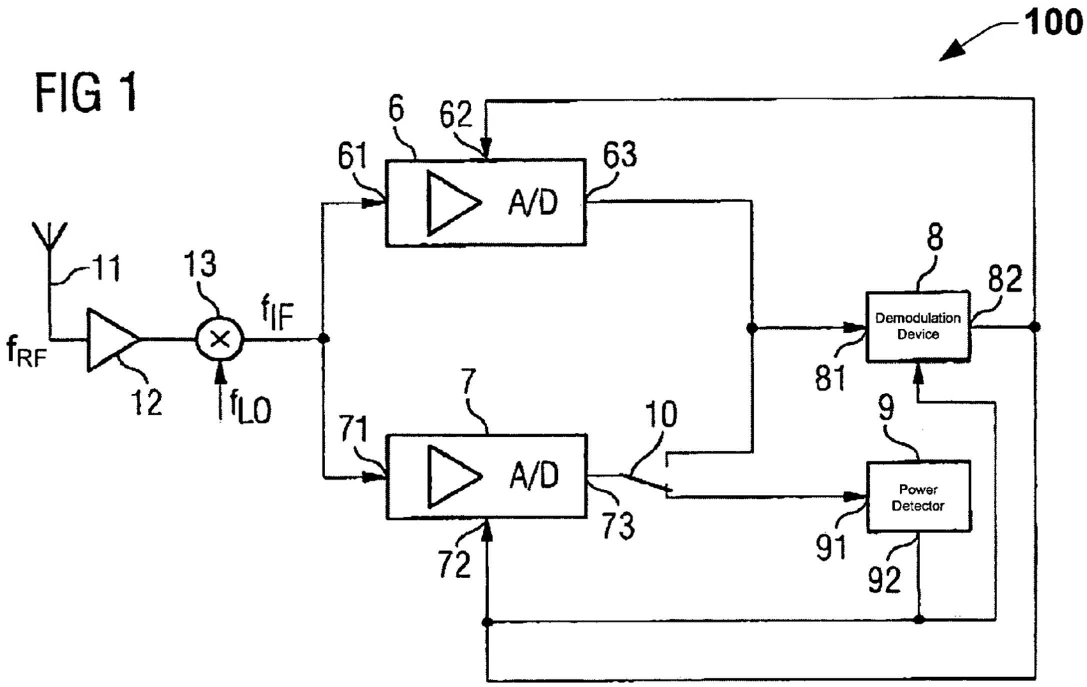


FIG 1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61
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A/D
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13
f_{IF}
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82
f_{RF}
Demodulation Device
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f_{LO}
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10
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71
A/D
Power Detector
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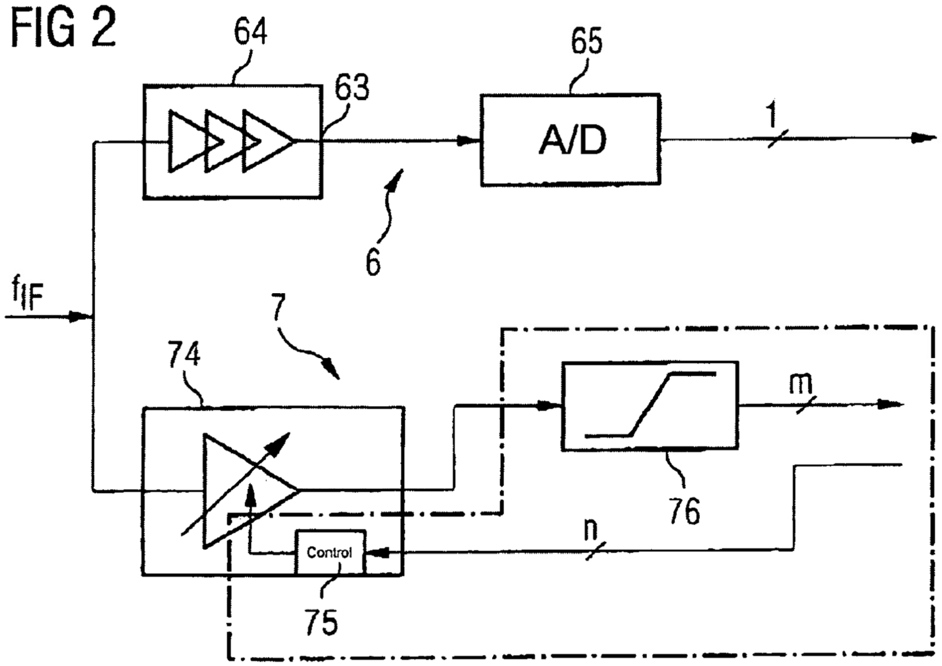
91
72
92

FIG 2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65
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A/D
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6
f_{IF}
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n
Control
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FIG 3

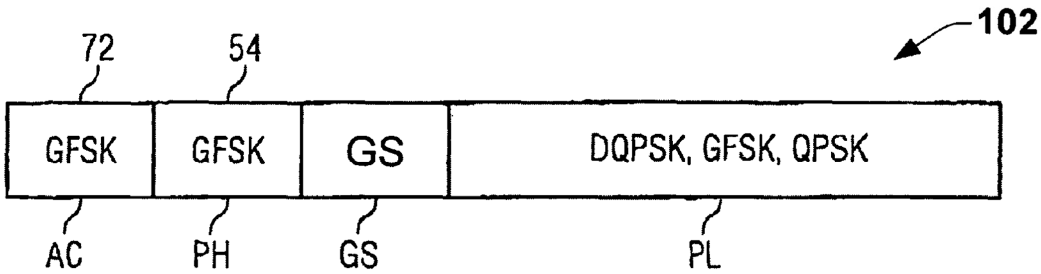


FIG 4

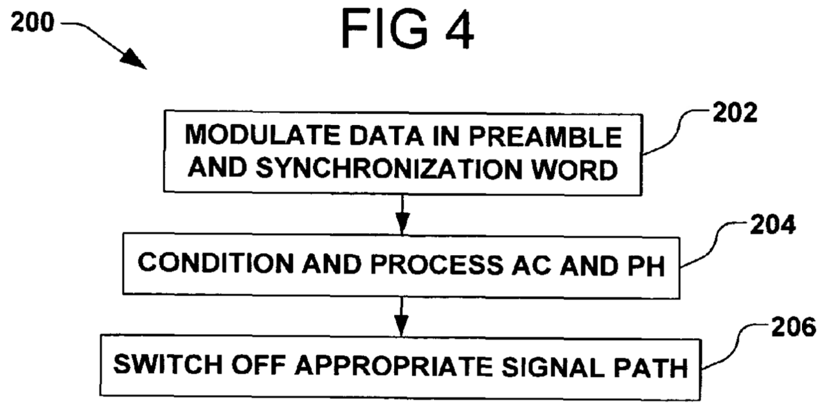
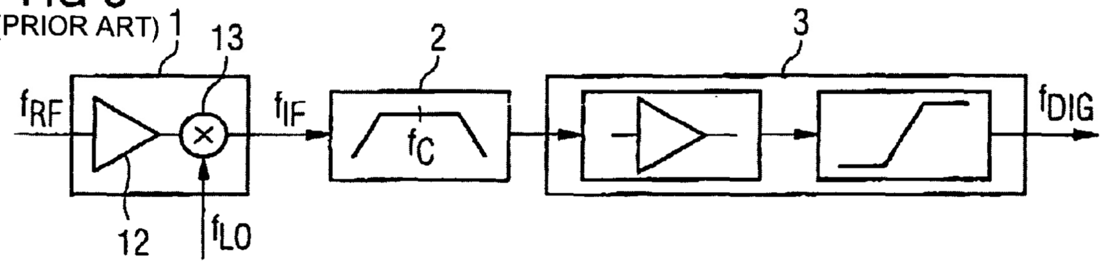


FIG 5
(PRIOR ART)



SIGNAL PROCESSING METHOD, PARTICULARLY IN A RADIO-FREQUENCY RECEIVER, AND SIGNAL CONDITIONING CIRCUIT

REFERENCE TO RELATED APPLICATIONS

This application is a continuation of PCT/DE2005/000845 filed May 4, 2005 which was not published in English, that claims the benefit of the priority date of German Patent Application No. DE 10 2004 021 867.6, filed on May 4, 2004, the contents of which both are herein incorporated by reference in their entireties.

FIELD OF THE INVENTION

The invention relates to a method for signal processing, particularly in a receiver. The invention further relates to a signal conditioning circuit.

BACKGROUND OF THE INVENTION

Some modern communication standards have the capability of transmitting information with a variable data rate. One example of this is the Bluetooth communication standard. In this standard, various types of modulation are provided for transmitting various data rates. For a data transmission rate of 1 Mbit/s, frequency shift keying (GFSK modulation) is used as a type of modulation. For medium and high data transmission rates of 2 to 3 Mbit/s, a π/4 DQPSK and 8 DPSK modulation, respectively, are provided as types of modulation. Whereas in pure frequency shift keying, information is only transmitted over the time of a zero transition, an amplitude and a phase of the signal are changed simultaneously in the two π/4 DQPSK and 8 DPSK types of modulation which produces different requirements for a receiver.

FIG. **5** shows a typical block diagram of a receiver system for such a mobile communication standard. The received signal with a frequency f_{RF} is amplified in a radio-frequency input stage **1** with a low-noise amplifier **12** and converted to an intermediate frequency f_{IF} by means of a mixer **13**. For this purpose, the mixer **13** uses a local oscillator signal with the frequency f_{LO}. The signal converted to the intermediate frequency f_{IF} is supplied to a complex channel filter **2** which is arranged as a band-pass filter.

The filtered signal is amplified in a signal conditioning circuit **3** and digitized in a downstream analog/digital converter. In the signal conditioning circuit **3**, the filtered signal is amplified up to a level which is suitable for the subsequent analog and digital signal processing. For example, the resolution of the downstream analog/digital converter is utilized by the gain set. The receiver path presented here contains a number of distributed amplifier stages having, in each case, individual gain factors which result in a common gain factor.

Depending on the mobile radio standard used, the gain factors in the individual stages are designed differently for optimum reception. For example, in the case of pure frequency modulation in which frequency shift keying is used, it is sufficient to work with limiting amplifier stages since there is no information contained in the signal amplitude. The amplifier stages can be operated, therefore, in limiting mode. Higher-valued modulation methods such as the π/4 DQPSK and 8 DPSK method described, however, also use amplitude and phase information. The amplification of a signal modulated with such a modulation method therefore requires a

To improve the signal/noise ratio of the received signal further, it is suitable to amplify the signal greatly, as far as possible before any complex signal processing. However, it is important to note that high input levels of a received signal are also amplified linearly so that any amplitude information which may be present is not corrupted. For this reason, modern communication systems use active control of the amplification in which, for example, the level of the input signal is determined and its amplification is adjusted in dependence thereon. The associated power measurement, called RSSI (radio signal strength indicator) measurement, allows active control.

A particular problem occurs with a mobile radio standard which changes the data rate/type of modulation variably during a transmission. Such an example is the new version of the Bluetooth mobile radio standard which operates in packet mode. In this mode, header and packet information, in particular, is first transmitted in data packets with a low GFSK data rate and GFS modulation and then the payload data are transmitted with the same or a medium or higher data rate with π/4 DQPSK or 8 DPSK modulation. It is thus necessary to determine the receive level of the received data packet and from this to suitably adjust the gain factor in dependence on the type of modulation of the payload data in order to prevent amplitude or phase errors.

Accordingly, a need exists for a simplified method for determining a suitable gain factor, as well as a corresponding signal conditioning circuit and method of use thereof.

SUMMARY OF THE INVENTION

The present invention overcomes the limitations of the prior art by providing a method for signal processing, and a signal conditioning circuit and method of using the signal conditioning circuit in a simple and efficient manner. Accordingly, the following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is intended to neither identify key or critical elements of the invention nor delineate the scope of the invention. Its purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented later.

In accordance with one aspect of the present invention a method and apparatus are provided, wherein a suitable gain factor is determined in a simple manner. According to the invention, a first signal path with an amplifier and a second signal path with an amplifier are provided. The amplifier of the second signal path has a controllable gain factor. A signal is applied to the first and second signal path, wherein the signal is amplified in the first signal path. Concurrently, the signal on the second signal path is amplified by the gain factor and a power of the signal applied to the second signal path is determined.

The power determined, for example, can be used for later adjustment of a gain factor. As a result, a demodulation and measurement of the signal level is advantageously carried out on two different signal paths. This is advantageous since errors during the demodulation, which can be caused by level measurement, are thus generally avoided. In particular, an optimum gain setting can be found and adjusted on the second signal path without demodulation errors occurring due to a settling process of the amplifier stages.

Demodulation, for example, is understood to be signal of the received signal into a baseband, and its separation into an in-phase component and a quadrature component.

In one embodiment, one of the two signal paths can also be switched off depending on information used as an identifier in the data content of the demodulated signal. The subsequent received signal can be amplified and processed further via the one signal path. This, for example, allows the current consumption of a circuit operating in accordance with this principle to be distinctly lowered because only the amplifier path needed for the amplification and the demodulation of the signal is active. Further, one of the two signal paths can thus be selected in dependence on the type of modulation. In addition, an amplifier on the first signal path can be arranged in a particularly simple and current-saving manner as a limiting amplifier having only a few stages via the present invention.

The method of the present invention can be used particularly advantageously for receiving signals with a variable data rate or type of modulation. The method, for example, can be utilized for receiving signals according to the Bluetooth mobile radio standard. In this context, a signal, such as a Bluetooth signal, is amplified with a gain factor on the second signal path and the power of the received signal is determined. On the first signal path, the signal is amplified and suitably demodulated at least partially during the demodulation process.

The determined power allows a suitable gain factor to be set for an optimum amplification at a later time of transmitted payload data in the signal, such as in the Bluetooth signal. Concurrently, information used as an identifier about the type of modulation of the signal used for the payload data can be obtained by the demodulation. In a Bluetooth signal, for example, information at the beginning of the signal is advantageously evaluated for this purpose. One of the two signal paths, for example, is switched off in dependence on the information obtained.

In a preferred embodiment, the power of a signal applied in the second signal path is determined by converting the signal into a value- and time-discrete signal. Subsequently, the amplitude of the converted signal is determined.

In accordance with another aspect of the invention, a signal conditioning circuit is provided, wherein the signal conditioning circuit comprises, apart from a first signal path with a first amplifier and a second signal path with a second amplifier with adjustable gain factor, a first and a second operating state which can be assumed. In the first operating state which can be assumed, the first signal path is arranged for amplifying a signal present and for providing the amplified signal for demodulation. In the first operating state which can be assumed, the second signal path is also arranged for amplifying the signal present and for determining a power of the signal present. In the second operating state which can be assumed by the signal conditioning circuit, either the first or the second signal path is arranged for amplifying the signal present and for demodulating the amplified signal. In this operating state, the other signal path is arranged for reducing a current or power consumption. In the second operating state which can be assumed, one of the two signal paths is suitably inactive, whereas the other signal path is arranged for amplifying and for providing the amplified signal in a suitable manner for demodulation.

According to one exemplary aspect, the signal conditioning circuit of the invention can be advantageously used for determining the level of a received signal, and the measured power can be delivered as radio signal strength indicator signal (RSSI) to other signal-processing circuits, such as the demodulation device. Due, at least in part, to the parallel

individual amplifier stages, thus generally avoiding having to change the amplification during the reception of payload data and thus any possible loss of data.

In a preferred embodiment, the amplifier on the first signal path is arranged as a limiting amplifier. In another embodiment, the first signal path contains an analog/digital converter for the analog/digital conversion of a signal received and amplified via the first amplifier. For example, the analog/digital converter can be arranged as a ΣΔ (sigma delta) modulator.

In yet another embodiment of the invention, the second amplifier has an adjusting input for supplying a signal which adjusts the gain factor of the second amplifier. The second amplifier is thus arranged as an amplifier which can be programmed with its gain factor.

In accordance with another exemplary aspect of the invention, the signal conditioning circuit is arranged for receiving and for processing signals coded in accordance with the Bluetooth mobile radio standard. As an alternative, the signal conditioning circuit is arranged for processing signals having different types of modulation.

Thus, according to the invention, the first signal path can be arranged for receiving and demodulating payload data with low data rate and GFSK type of modulation, whereas the second signal path can be used for receiving payload data with a high data transmission rate. Thus, during the transmission of payload data in one example, only one path is ever activated. This reduces the current consumption and the power consumption. In addition, in the case of a data transmission with low data transmission rate, the first signal path is used, wherein the current consumption thereof is already reduced via the arrangement with a simple amplifier. Since the first signal path does not need to determine any data relating to the power of the signal present, it can be configured in a correspondingly simple manner. Further, the signal conditioning circuit can be arranged as an integrated circuit in a single semiconductor body.

To the accomplishment of the foregoing and related ends, the invention comprises the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative embodiments of the invention. These embodiments are indicative, however, of a few of the various ways in which the principles of the invention may be employed. Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a block diagram of a signal conditioning circuit in accordance with one aspect of the invention.

FIG. **2** illustrates a block diagram of a first and second signal path in accordance with another aspect of the invention.

FIG. **3** illustrates a structural overview of a signal packet according to the Bluetooth mobile radio standard.

FIG. **4** illustrates an exemplary method for signal processing according to the present invention.

FIG. **5** illustrates a block diagram of a conventional receiving path.

DETAILED DESCRIPTION OF THE INVENTION

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.