Description

The invention relates to a receiver for receiving an angle-modulated input signal including a diversity switch having n inputs, a control input and an output, the receiver further including a HF-unit coupled to the output of the diversity switch, a demodulator coupled to the HF-unit and a multipath transmission detector coupled to the HF-unit and to the control input.

Such receivers are generally known in the art.

A multipath transmission detector suitable for use in such diversity receivers is disclosed in German "Offenlegungsschrift" 3,334,735. Receivers of such a type are, for example, in the form of FM-receivers and are generally coupled to a plurality of antennas. Depending on the multipath distortion of an input signal incoming on an antenna, the receiver is switched by means of the multipath transmission detector to one or more other antennas receiving an input signal having a lower multipath distortion. Prior multipath transmission detectors include an AM-detector and/or a frequency interference peak detector. In said German Offenlegungsschrift multipath distortion is detected at the simultaneous occurrence of sharp amplitude minima and frequency interference peaks in the received input signal. Prior art receivers including multipath transmission detectors have the disadvantage that in many cases they detect multipath distortion erroneously, in response to which the diversity system of such receivers switches too often, which detrimentally affects the sound quality of these receivers because of the fact that generally audible phase jumps occur during the change-over actions.

The invention has for its object to increase the reliability with which multipath distortion is detected in such receivers. According to the invention, the receiver is characterized in that the receiver includes a frequency window circuit having a frequency window the bandwidth of which is located within the bandwidth of the receiver and including a level detector, which frequency window circuit is coupled to the HF-unit or coupled to the demodulator, the frequency window circuit being coupled to the multipath transmission detector for approving the detection of a multipath transmission signal by the multipath transmission detector when the instantaneous frequency of the angle-modulated input signal is located within the window and for rejecting this detection when the instantaneous frequency is located outside the window.

If in the receiver according to the invention the instantaneous frequency of the angle-modulated input signal is located within the window bandwidth of the frequency window circuit this circuit will apply an enable signal to indicate that any multipath distortion detected by the multipath detector is sufficiently reliable. Therefore, a receiver including a multipath detector and a frequency window circuit in accordance with the invention will less often switch superfluously.

The invention further relates to a multipath transmission detector including a frequency window circuit for use in the receiver according to the invention.

The invention will now be described in greater detail by way of example with reference to the accompanying drawing. Therein:

Figure 1 shows embodiments of the invention;

Figure 2a is a frequency curve representing the bandwidth of the receiver of Figure 1;

Figure 2b is a frequency-versus-time curve of the instantaneous frequency of an angle-modulated signal produced by a frequency window circuit shown in Figure 1;

Figure 2c shows an angle-modulated signal produced by a frequency window circuit shown in Figure 1, as a function of time.

Figure 1 shows a receiver 1 which is suitable for receiving angle-modulated input signals such as phase or frequency modulated signals. Receiver 1 may be susceptible to multipath distortions caused by receiving from several directions signals reflected also by obstacles, such as mountains and buildings. In for example, FM-reception such reflected signals produce distortions in the form of sharp amplitude minima and associated frequency interference peaks, as is described in an article by M.S. Corrington, entitled: "Frequency-Modulation Distortion Caused by Multipath Transmission", published in proceedings of the IRE, pages 87-891, December 1945.

As will be described hereinafter, multipath distortion is very annoying, particularly in car radios. Diversity receivers having a plurality of antennas have been developed in order to counteract the annoying multipath distortion. In such a diversity receiver a selection is made, on the basis of the multipath distortion detected in the received input signals, of little-distorted input signals originating from one or more antennas, for which purpose a switch must be made from one antenna to another. This switching action is generally audible and must be limited.

The receiver 1 includes a diversity switch 3 having a control input 2, and n inputs and one output, a unit 4 connected to the switch 3 and comprising an HF stage and a mixer stage, an intermediate frequency amplifier unit 5 connected to this mixer stage and, connected to the intermediate frequency unit, a demodulator 6 which is connected to a loudspeaker via, for example, a LF amplifier, not shown. The diversity switch 3 is connected to n antennas 7-1 to 7-n. In addition, the receiver 1 includes a multipath transmission detector 8 which on detecting multipath distortion applies a control signal to the control input 2 of the diversity switch 3. With the aid of this control signal a switch is made to different combinations of antennas. In this manner the receiver 1 always searches for an input signal of an appropriate quality.

To this end, the multipath detector 8 may comprise an AM detector 9. As in the angle-modulation principle the amplitude of an angle-modulated input signal is constant, multipath

distortion which causes the waves received by an antenna or an antenna combination to quench each other by interference, in response to which sharp amplitude minima occur, can be detected with such an AM detector may comprise only a frequency interference peak detector 10 detecting by means of amplitude detection frequency interference peaks occurring in the received signal, for example, the demodulated signal produced by the demodulator 6. As both phenomena, i.e. the amplitude minima and the frequency interference peaks can occur simultaneously in multipath distortion, both an AM detector 9 and an interference peak detector 10 can be used in the multipath detector 8 and the detection results can be simply combined with the aid of a weighting circuit 11 as shown in Figure 1 and known per se from German Offenlegungsschrift DE-A-3,334,735. Depending on the levels of the signals produced by the two detectors 9, 10, the weighting circuit 11 applies, at the simultaneous occurrence of these two phenomena, a control signal to the control input 2 in response to which the switch 3 changes-over. Particularly when used as a car radio, the receiver 1 is a narrow-band receiver. This requirement is more specifically dictated by the fact that the transmit frequencies of transmitters are close to each other. So as to increase the selectivity of the receiver 1, the bandwidth of all the filters, such as the tuning and intermediate frequency filters in the units 4 and 5 of the receiver 1, must be comparatively narrow, a certain degree of distortion because of this narrow-band nature results, however, in that a portion of the side-band of the angle-modulated signal are not allowed to pass. This causes the signal filtered thus not to have a constant amplitude but rather to exhibit an amplitude modulation. A further consequence of the narrow-band nature is that in response to fast phase changes in the amplitude-modulated signal after demodulation the demodulated signal also contains what are commonly referred to as frequency interference peaks. This has for its result that particularly for highly modulated signals the multipath detector 8 detects an amplitude minimum and a frequency interference peak and then erroneously produces a control signal which results in unwanted switching of the diversity switch 3.

This disadvantage is counteracted by providing the receiver 1 with a frequency window circuit 12 having a frequency window the bandwidth of which is located of the receiver within the bandwidth of the receiver 1 preferably symmetrically around the central frequency bandwidth. It has for its function to determine whether the instantaneous frequency of the received, angle-modulated input signal is within the window bandwidth of the frequency window. For the time in which this is the case for a received signal, the frequency window circuit 12 applies an enable signal to terminal 13 to indicate that any multipath distortion detected by the multipath detector 8 is sufficiently reliable, as this distortion now is not the result of the fact that the receiver 1 is a narrow-band receiver. The terminal 13 is connected to the multipath detector 8.

In a first embodiment the frequency window circuit 12 is then connected to the demodulator 6.

In the first embodiment the enable signal is generated as long as the instantaneous frequency is located within the bandwidth of the frequency window circuit 12, and in the second embodiment as long as the instantaneous amplitude of the demodulated input signal is located within the levels of level detector 14 and consequently the instantaneous frequency of the angle-modulated input signal is located within the bandwidth of the frequency window circuit 12. The bandwidth of the frequency window circuit 12 is then, for example, approximately 50 kHz, this being located in the centre of the bandwidth of the receiver 1, which may amount to approximately 200 kHz. In such a case the levels determined by the level detector 14 have been chosen such that they correspond to a frequency window having a bandwidth of approximately 50 kHz.

Figure 2 shows graphs to illustrate the operation of the frequency window circuit 12.

Figure 2a shows a frequency curve representing the bandwidth of the receiver 1. Figure 2b shows a frequency-versus-time curve of the instantaneous frequency of the angle modulated input signal. The bandwidth having cut-off values f_1, f_2 of the frequency window circuit 12 is located symmetrically around the central frequency f_c and within the receiver bandwidth shown in Figure 2a. Figure 2c shows an enable signal V_{13} as a function of time, which signal is supplied from the terminal 13 and produced by the frequency window circuit 12. In the areas I the instantaneous frequency of the input signal is located between the cut-off values f_1, f_2; accordingly, an enable signal is produced in these areas I by the level detector 14. This results in a frequency interference peak M due to multipath distortion and an associated amplitude minimum, not shown, detected in detector 9, the frequency interference peak occurring in an area I, indeed being detected as a multipath distortion. In the areas II the instantaneous frequency is located outside the frequency range from f_1 to f_2 of the frequency curve shown in Figure 2a. On the one hand, as described already in the foregoing, this results in amplitude minima when located at the edges of the curve shown in Figure 2a and in a frequency interference peak because of an increase in noise caused by a decrease of the signal-to-noise radio. The frequency interference peak detector 10 can easily be triggered by the noise increase, and the amplitude detector 9 by an amplitude minimum. But on the other hand the absence of the enable signaling area II will inhibit triggering of the multipath detector 8 via terminal 13; consequently distortion is not erroneously detected as multipath distortion. It is an advantage that, in those systems which receive weak signals with comparatively much noise and where in areas II this noise adds to the said increase of the noise due to the limited bandwidth

of the receiver 1, the detection of multipath distortion is significantly improved.

A still further improvement of the multipath distortion detection is accomplished when the receiver 1 is provided with a frequency window circuit 12 which includes a low-pass filter 15, connected to the demodulator 6, which filter is connected in turn to the level detector 14. This cascade-arrangement has for its effect that the frequency curve shown in Figure 2b is smoothed to some extent, whereby the noise sensitivity on detection of multipath distortion decreases still (her and a further improvement of the reliability with which multipath distortion is determined is obtained. This is, for example, the case for frequency interference peak K. Because of the introduction of the frequency window circuit 12 frequency interference peak K would erroneously not be detected as multipath distortion, because this frequency interference peak briefly exceeds the frequency limit f_2. The use of the low-pass filter 15 causes as is shown on a larger scale in the inset, this frequency interference peak to be partly smoothed as illustrated by the broken-line curves, as a result of which the peak stays within the frequency window so that multipath distortion is correctly determined.

From the above description it will be apparent that it if wanted possible to control in some degree instantaneously the thresholds of the level detectors in the AM detector 9 and in the frequency interference peak detector 10, in dependence on the deviation in the central frequency.

Claims

1. A receiver (1) for receiving an angle-modulated input signal including a diversity switch (3) having n inputs, a control input (2) and an output, the receiver (1) further including a HF-unit (4) coupled to the output of the diversity switch (3), a demodulator (6) coupled to the HF-unit (4) and a multipath transmission detector (8) coupled to the HF-unit (4) and to the control input (2), characterized in that the receiver (1) includes a frequency window circuit (12) having a frequency window the bandwidth of which is located within the bandwidth of the receiver (1) and including a level detector (14), which frequency window circuit (12) is either coupled to the HF-unit (4) or coupled to the demodulator (6), the frequency window circuit (12) being coupled to the multipath transmission detector (8) for approving the detection of a multipath transmission signal by the multipath transmission detector (8) when the instantaneous frequency of the angle modulated input signal is located within the window and for rejecting this detection when the instantaneous frequency is located outside the window.

2. A receiver (1) as claimed in claim 1, characterized in that the level detector (14) is coupled to the HF-unit (4) via a bandpass filter.

3. A receiver (1) as claimed in claim 1, characterized in that the level detector (14) is coupled to the demodulator (6) via a lowpass filter (15).

4. A multipath transmission detector (8) including a frequency window circuit (12) for use in the receiver (1) as claimed in any one of the preceding claims.

Patentansprüche

1. Empfänger (1) zum Empfangen eines winkelmodulierten Eingangssignals mit einem Diversity-Schalter (3) mit n Eingängen, einem Steuereingang (2) und einem Ausgang, wobei der Empfänger (1) weiterhin eine mit dem Ausgang des Diversity-Schalters (3) gekoppelte HF-Einheit (4), einen mit der HF-Einheit (4) gekoppelen Demodulator (6) und einen mit der HF-Einheit (4) sowie mit dem Steuereingang (2) gekoppelten Mehrstrecken-Übertragungsdetektor (8) aufweist, dadurch gekennzeichnet, daß der Empfänger (1) eine Frequenzfensterschaltung (12) mit einem Frequenzfenster, dessen Bandbreite innerhalb der Bandbreite des Empfängers (1) liegt und mit einem Pegeldetektor (14), wobei die Frequenzfesterschaltung (12) entweder mit der HF-Einheit (4) oder mit dem Demodulator (6) gekoppelt ist, wobei diese Frequenzfensterschaltung (12) mit dem Mehrstrecken-Übertragungsdetektor (8) gekoppelt ist zum Genehmigen der Detektion eines Mehrstrecken-Übertragungssignals durch den Mehrstrecken-Übertragungsdetektor (8), wenn die Ist-Frequenz des winkelmodulierten Eingangssignals innerhalb des Fensters liegt, sowie zum Zurückweisen dieser Detektion, wenn die Ist-Frequenz außerhalb des Fensters liegt.

2. Empfänger (1) nach Anspruch 1, dadurch gekennzeichnet, daß der Pegeldetektor (14) über ein Bandpaßfilter mit der HF-Einheit (4) gekoppelt ist.

3. Empfänger nach Anspruch 1, dadurch gekennzeichnet, daß der Pegeldetektor (14) über ein Tiefpaßfilter (15) mit dem Demodulator (6) gekoppelt ist.

4. Mehrstrecken-Übertragungsdetektor (8) mit einer Frequenzfensterschaltung (12) zum Gebrauch in dem Empfänger nach einem der vorstehenden Ansprüche.

Revendications

1. Récepteur (1) destiné à recevoir un signal d'entrée modulé en angle comprenant un commutateur de diversité (3) comportant n entrées, une entrée de commande (2) et une sortie, le récepteur (1) comprenant, en outre, une unité HF (4) couplée à la sortie du commutateur de diversité (3), un démodulateur (6) couplé à l'unité HF (4) et un détecteur de transmission par trajets multiples (8), couplé à l'unité HF (4) et à l'entrée de commande (2), caractérisé en ce que le récepteur (1) comprend un circuit à fenêtre de fréquence (12) présentant une fenêtre de fréquence dont la largeur de bande est située dans la largeur de bande du récepteur (1) et comprenant un détecteur de niveau (14), ce circuit à fenêtre de fréquence (12) étant couplé à l'unité HF (4) ou au démodulateur (6) et étant couplé au détecteur de

of the receiver 1, the detection of multipath distortion is significantly improved.

A still further improvement of the multipath distortion detection is accomplished when the receiver 1 is provided with a frequency window circuit 12 which includes a low-pass filter 15, connected to the demodulator 6, which filter is connected in turn to the level detector 14. This cascade-arrangement has for its effect that the frequency curve shown in Figure 2b is smoothed to some extent, whereby the noise sensitivity on detection of multipath distortion decreases still ...her and a further improvement of the ...rability with which multipath distortion is determined is obtained. This is, for example, the case for frequency interference peak K. Because of the introduction of the frequency window circuit 12 frequency interference peak K would erroneously not be detected as multipath distortion, because this frequency interference peak briefly exceeds the frequency limit f_2. The use of the low-pass filter 15 causes as is shown on a larger scale in the inset, this frequency interference peak to be partly smoothed as illustrated by the broken-line curves, as a result of which the peak stays within the frequency window so that multipath distortion is correctly determined.

From the above description it will be apparent that it if wanted possible to control in some degree instantaneously the thresholds of the level detectors in the AM detector 9 and in the frequency interference peak detector 10, in dependence on the deviation in the central frequency.

Claims

1. A receiver (1) for receiving an angle-modulated input signal including a diversity switch (3) having n inputs, a control input (2) and an output, the receiver (1) further including a HF-unit (4) coupled to the output of the diversity switch (3), a demodulator (6) coupled to the HF-unit (4) and a multipath transmission detector (8) coupled to the HF-unit (4) and to the control input (2), characterized in that the receiver (1) includes a frequency window circuit (12) having a frequency window the bandwidth of which is located within the bandwidth of the receiver (1) and including a level detector (14), which frequency window circuit (12) is either coupled to the HF-unit (4) or coupled to the demodulator (6), the frequency window circuit (12) being coupled to the multipath transmission detector (8) for approving the detection of a multipath transmission signal by the multipath transmission detector (8) when the instantaneous frequency of the angle modulated input signal is located within the window and for rejecting this detection when the instantaneous frequency is located outside the window.

2. A receiver (1) as claimed in claim 1, characterized in that the level detector (14) is coupled to the HF-unit (4) via a bandpass filter.

3. A receiver (1) as claimed in claim 1, characterized in that the level detector (14) is coupled to the demodulator (6) via a lowpass filter (15).

4. A multipath transmission detector (8) including a frequency window circuit (12) for use in the receiver (1) as claimed in any one of the preceding claims.

Patentansprüche

1. Empfänger (1) zum Empfangen eines winkelmodulierten Eingangssignals mit einem Diversity-Schalter (3) mit n Eingängen, einem Steuereingang (2) und einem Ausgang, wobei der Empfänger (1) weiterhin eine mit dem Ausgang des Diversity-Schalters (3) gekoppelte HF-Einheit (4), einen mit der HF-Einheit (4) gekoppelen Demodulator (6) und einen mit der HF-Einheit (4) sowie mit dem Steuereingang (2) gekoppelten Mehrstrecken-Übertragungsdetektor (8) aufweist, dadurch gekennzeichnet, daß der Empfänger (1) eine Frequenzfensterschaltung (12) mit einem Frequenzfenster, dessen Bandbreite innerhalb der Bandbreite des Empfängers (1) liegt und mit einem Pegeldetektor (14), wobei die Frequenzfesterschaltung (12) entweder mit der HF-Einheit (4) oder mit dem Demodulator (6) gekoppelt ist, wobei diese Frequenzfensterschaltung (12) mit dem Mehrstrecken-Übertragungsdetektor (8) gekoppelt ist zum Genehmigen der Detektion eines Mehrstrecken-Übertragungssignals durch den Mehrstrecken-Übertragungsdetektor (8), wenn die Ist-Frequenz des winkelmodulierten Eingangssignals innerhalb des Fensters liegt, sowie zum Zurückweisen dieser Detektion, wenn die Ist-Frequenz außerhalb des Fensters liegt.

2. Empfänger (1) nach Anspruch 1, dadurch gekennzeichnet, daß der Pegeldetektor (14) über ein Bandpaßfilter mit der HF-Einheit (4) gekoppelt ist.

3. Empfänger nach Anspruch 1, dadurch gekennzeichnet, daß der Pegeldetektor (14) über ein Tiefpaßfilter (15) mit dem Demodulator (6) gekoppelt ist.

4. Mehrstrecken-Übertragungsdetektor (8) mit einer Frequenzfensterschaltung (12) zum Gebrauch in dem Empfänger nach einem der vorstehenden Ansprüche.

Revendications

1. Récepteur (1) destiné à recevoir un signal d'entrée modulé en angle comprenant un commutateur de diversité (3) comportant n entrées, une entrée de commande (2) et une sortie, le récepteur (1) comprenant, en outre, une unité HF (4) couplée à la sortie du commutateur de diversité (3), un démodulateur (6) couplé à l'unité HF (4) et un détecteur de transmission par trajets multiples (8), couplé à l'unité HF (4) et à l'entrée de commande (2), caractérisé en ce que le récepteur (1) comprend un circuit à fenêtre de fréquence (12) présentant une fenêtre de fréquence dont la largeur de bande est située dans la largeur de bande du récepteur (1) et comprenant un détecteur de niveau (14), ce circuit à fenêtre de fréquence (12) étant couplé à l'unité HF (4) ou au démodulateur (6) et étant couplé au détecteur de

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transmission par trajets multiples (8) pour approuver la détection d'un signal de transmission par trajets multiples par le détecteur de transmission par trajets multiples (8) lorsque la fréquence instantanée du signal d'entrée modulé en angle est située dans la fenêtre et pour rejeter cette détection lorsque la fréquence instantanée est située en dehors de la fenêtre.

2. Récepteur (1) suivant la revendication 1, caractérisé en ce que le détecteur de niveau (14) est couplé à l'unité HF (4) par l'intermédiaire d'un filtre passe-bande.

3. Récepteur (1) suivant la revendication 1, caractérisé en ce que le détecteur de niveau (14) est couplé au démodulateur (6) par l'intermédiaire d'un filtre passe-bas (15).

4. Détecteur de transmission par trajets multiples (8) comprenant un circuit à fenêtre de fréquence (12) destiné à être utilisé dans le récepteur (1) suivant l'une quelconque des revendications précédentes.

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