EUROPEAN PATENT SPECIFICATION

Date of publication and mention of the grant of the patent:

Application number: 92303580.2

Date of filing: 22.04.1992

Equaliser, operable in decision-feedback or fractional modes
Entzerrer, der in entscheidungsrückgekoppelter Form oder fraktionierter Form arbeiten kann
Egalisateur, fonctionnant soit en forme de décision récursive, soit en forme fractionnaire

Designated Contracting States:
CH DE ES FR GB IT LI NL

Priority: 10.05.1991 JP 105992/91

Date of publication of application:

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  JOURNAL vol. 22, no. 4, September 1986,

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BACKGROUND OF THE INVENTION

The present invention relates to a data receiving system to be used for a portable digital telephone set, a car digital telephone set or the like.

Portable telephone systems have been progressively digitalized in the recent years and development of digital data receiving units has been promoted. Under this circumstance, the use of equalizers in the portable telephone systems is now essential and unavoidable in Europe. Since portable telephone sets are driven by batteries, it is necessary to develop receiving units requiring small power consumption. Therefore, development of data receiving units including equalizers with less operation for signal processing is more important.

Conventional data receiving units will be explained below.

Fig. 1 shows a structure of the main part of the conventional data receiving unit. In Fig. 1, 21 designates a receiving antenna, 22 a receiving filter and 23 an equalizer.

Operation of the above prior-art example will be explained. Referring to Fig. 1, a signal received by the receiving signal 21 is processed by the receiving filter 22 so that a signal of only a desired channel is taken out. This extracted signal becomes an equalizer input 25 and is inputted to the equalizer 23. The equalizer 23 removes a distortion of a transmission path from the signal outputted from the receiving filter 22 and outputs a received data 24 with small error. When the signal is being transmitted after having been modulated by the MSK (Minimum Shift Keying) system or the GMSK (Gaussian-filtered Minimum Shift Keying) system or the like, T, which is the time necessary for transmitting one-bit signal, becomes T = (1/transmission rate).

Configuration examples of the equalizer used for the above data receiving unit will be explained below with reference to Figs. 2A to 2C. Fig. 2A shows an example of a fractional interval equalizer. Fig. 2B shows an example of a linear decision feedback equalizer, and Fig. 2C shows an example of a fractional interval decision feedback equalizer. In each of these drawings, 26 designates a delay unit (T/2), 27 a delay unit (T), 28 an amplifier, 29 an adder and 30 a discriminator. A number of taps and an interval of the fractional interval equalizer are different depending on the conditions under which these units are used.

The fractional interval equalizer will be explained. In Fig. 2A, the equalizer input 25 is first applied to the delay units 26 and is stored in a delay line of a fractional interval. The equalizer input is then weighted to compensate a distortion of a transmission path by the amplifier 28, and is added together by the adder 29. Plus or minus of an output from the adder 29 is discriminated by the discriminator 30 so that the received data 24 with small error is produced. Since this equalizer has fractional intervals for taps, or tap intervals are sampled in fine fractions, it is possible to handle data of a wide range. Therefore, this equalizer can compensate not only a distortion due to a multipath frequency selective fading but also a fading due to an interference of adjacent waves.

The linear decision feedback equalizer will be explained below. In Fig. 2B, the operation of the equalizer is the same as the operation of the equalizer in Fig. 2A, except that the forward side of the equalizer or the portion above the adder 29 in Fig. 2B, has a symbolic interval (T) for the delay quantity of the delay unit 27. At the backward side of the equalizer, or at the portion below the adder 29, the received data 24 is stored in the delay unit 27, weighted by the amplifier 28 and is added by the adder 29. Since this equalizer has the backward side, it can reduce error rates of the received data 24 further than an equalizer having only the fractional interval equalizer or the forward side, for a frequency selective fading (when the delayed wave is smaller than the main wave). However, this equalizer can not compensate a distortion due to an interference of adjacent waves.

Next, the fractional interval decision feedback equalizer will be explained. In Fig. 2C, the operation of the forward side is the same as the operation of the fractional interval equalizer shown in Fig. 2A, and the operation of the backward side is the same as the operation of the linear decision feedback equalizer shown in Fig. 2B. Since this equalizer has the backward side, this has the same performance as that of the equalizer in Fig. 2B for a frequency selective fading. Further, since the forward side of this equalizer has fractional intervals, this equalizer can compensate a distortion due to an interference of adjacent waves.

However, according to the above-described prior-art data receiving units, there are following problems. The fractional interval equalizer is inferior to the decision feedback equalizer in the performance for a frequency selective fading, the linear decision feedback equalizer can not compensate a distortion due to an interference of adjacent waves, and the fractional interval decision feedback equalizer has a large volume of operation because of a large total number of taps involved.

EP-A-0166555 describes a digital data reproducing system which includes a transversal filter in which switches are used to select whether the filter should have fractionally spaced taps or taps spaced at the bit interval T.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a data receiving unit which can compensate, in a predetermined small operation volume, for both distortion due to a frequency selective fading and distortion due to an interference of adjacent waves.

According to the present invention there is provided
a data receiving system comprising:

receiving filter means including first, second and third filters, the first filter being arranged to extract a principal wave from a received signal applied thereto, the second filter being arranged to extract from the received signal, an adjacent wave to the principal wave and having a frequency higher than that of the principal wave, and the third filter being arranged to extract from the received signal, an adjacent wave to the principal wave and having a frequency lower than that of the principal wave; equalizer means responsive to the principal wave from the first filter and including a fractional interval equalizer for removing distortion caused by the adjacent waves from the principal wave and a linear decision feedback equalizer for removing distortion caused by a frequency selective fading therefrom; equalizer control means responsive to the principal wave from the first filter and the adjacent waves from the second filter and the third filter, for comparing power of the principal wave with that of the adjacent waves to select either one of said fractional interval equaliser and said linear decision feedback equaliser.

With the above structure, the data receiving system can select the linear decision feedback equalizer when the distortion due to the frequency selective fading is ruling and can select the fractional interval equalizer when the distortion due to the interference of the adjacent waves is ruling, so that the data receiving unit can compensate both the distortion due to the frequency selective fading and the distortion due to the interference of the adjacent waves, in a predetermined small operation volume.

The invention will be described now by way of example only with particular reference to the accompanying drawings. In the drawings:

Fig. 1 is a block diagram for showing the main part of the conventional data receiving unit;
Figs. 2A to 2C are block diagrams for showing examples of the equalizer used in the conventional data receiving unit;
Fig. 3 is a block diagram for showing the main part of the data receiving unit according to one embodiment of the present invention;
Fig. 4 is a block diagram for showing the equalizer according to the present embodiment;
Figs. 5A to 5C are frequency spectrum diagrams for showing the relationship between the principal wave and the adjacent waves, to explain the operation of the present embodiment; and
Fig. 6 is a diagram for showing another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 3 shows the configuration of one embodiment of the present invention. Referring to Fig. 3, 1 designates a receiving antenna and 2, 3 and 4 designate receiving filters. The receiving filter 2 takes out a signal (adjacent wave A) of the frequency higher than the frequency of the principal wave, the receiving filter 3 takes out the principal wave and uses its output as an equalizer input 13, and the receiving filter 4 takes out a signal (adjacent wave B) of the channel of the frequency lower than the frequency of the principal wave, 5 designates an equalizing controller which compares power of the signals taken out by the receiving filters 2, 3 and 4 respectively and controls an equalizer 6. The equalizer 6 includes a fractional interval equalizer and a linear decision feedback equalizer which are structured by delay units (T/2) 7, delay units (T) 8, amplifiers 9, an adder 10 and a discriminator 11, both the fractional interval equalizer and the linear decision feedback equalizer being capable of being selectively changed over by a selective switch 12, as shown in Fig. 4. In Fig. 4, 14 designates received data and 15 designates an equalizing control signal.

The operation of the above embodiment will be explained with reference to Figs. 3 to 5. In Figs. 3 and 4, when a signal has been received by the receiving antenna 1, a signal (adjacent wave A) of the channel with a higher frequency than the frequency of the principal wave is taken out by the receiving filter 2, and this signal is inputted to the equalizing controller 5. The principal wave is taken out by the receiving filter 3 and is applied as the equalizer input 13 to both the equalizer 6 and the equalizing controller 5. A signal (adjacent wave B) of the channel with a lower frequency than the frequency of the principal wave is taken out by the receiving filter 4 and is applied to the equalizing controller 5. The equalizing controller 5 then compares the power of these three kinds of signals and selectively decides whether the equalizer 6 is to be used as the fractional interval equalizer using the delay unit 7 or the equalizer 6 is to be used as the linear decision feedback equalizer using the delay unit 8. According to the present embodiment, the power of the adjacent wave A and the power of the adjacent wave B are added together as the total power of the adjacent waves, and this total power of the adjacent waves is compared with the power of the principal wave.

When there is no distortion due to a frequency selective fading and a distortion due to the adjacent waves is small as shown in Fig. 5A, power of the adjacent waves is small and, therefore, the linear decision feedback equalizer is selected. When a distortion due to the adjacent waves is ruling and there is no distortion due to a frequency selective fading (or when a distortion due to the adjacent waves is overwhelmingly large although there is a distortion due to a frequency selective fading) as shown in Fig. 5B, the fractional interval equalizer is
selected. When a distortion due to a frequency selective fading is ruling because a distortion due to the adjacent waves is small as shown in Fig. 5C, the linear decision feedback equalizer is selected as is the case in Fig. 5A. The result of a selection is informed to the equalizer 6 by the equalizing control signal 15 and the selective switch 12 of the equalizer 6 is controlled.

The equalizer input 13 is stored in the delay lines of the fractional intervals and symbolic intervals (T) by the delay units (T/2) 7 and the delay units (T) 8 in the equalizer 6. Data from each tap is selected such that, when the fractional interval equalizer has been selected by the change-over of the selective switch 12 based on the equalizing control signal 15, data from the delay line of fractional intervals is selected and when the linear decision feedback equalizer has been selected, data from the delay line with symbolic intervals is selected. The selected data is then inputted to the amplifier 9, is weighted to compensate a distortion of a transmission path, and is added together by the adder 10. Plus or minus of an output from the adder 10 is discriminated by the discriminator 11, and the result becomes the received data 14. When the linear decision feedback equalizer has been selected, the data becomes feedback data to the backward side. The received data 14 is then decoded.

As explained above, according to the present embodiment, the principal wave and adjacent waves A and B are taken out through the three kinds of receiving filters 2, 3 and 4 from the signal received by the receiving antenna 1. Based on the ratio of the power of these signals, the equalizing controller 5 selects the equalizer 6 to be used as the linear decision feedback equalizer when a distortion due to a frequency selective fading is ruling and selects the equalizer 6 to be used as the fractional interval equalizer when the influence of a distortion due to the adjacent waves is ruling. Therefore, there is an effect that both a distortion due to a frequency selective fading and a distortion due to an interference of the adjacent waves can be compensated in a predetermined small operation volume.

Although the fractional interval equalizer and the linear decision feedback equalizer are integrally structured according to the present embodiment, the fractional interval equalizer 16 and the linear decision feedback equalizer 17 may be separately structured as shown in Fig. 6. In this case, the structure shown in Fig. 2A and the structure shown in Fig. 2B may be directly used as the fractional interval equalizer 16 and the linear decision feedback type equalizer 17 respectively.

Claims

1. A data receiving system comprising:

receiving filter means including first, second and third filters (2, 3, 4), the first filter (3) being arranged to extract a principal wave from a received signal applied thereto, the second filter (2) being arranged to extract from the received signal, an adjacent wave to the principal wave and having a frequency higher than that of the principal wave, and the third filter (4) being arranged to extract from the received signal, an adjacent wave to the principal wave and having a frequency lower than that of the principal wave;

equalizer means (6) responsive to the principal wave from the first filter (3) and including a fractional interval equalizer for removing distortion caused by the adjacent waves from the principal wave and a linear decision feedback equalizer for removing distortion caused by a frequency selective fading therefrom;
equalizer control means (5) responsive to the principal wave from the first filter (3) and the adjacent waves from the second filter (2) and the third filter (4), for comparing power of the principal wave with that of the adjacent waves to select either one of said fractional interval equaliser and said linear decision feedback equaliser.

2. A data receiving system according to claim 1, wherein the equalizer control means (5) compares power of the principal wave with that of a sum of the adjacent waves.

Patentansprüche

1. Datenempfangssystem aufweisend:

Empfangseleakrichtungen, die erste, zweite und dritte Filter (2, 3, 4) beinhalten, wobei der erste Filter (3) angeordnet ist, um eine Hauptwelle aus einem an diesem anliegenden, empfangenen Signal zu extrahieren, der zweite Filter (2) angeordnet ist, um aus dem empfangenen Signal eine Welle zu extrahieren, die zur Hauptwelle benachbart liegt und eine höhere Frequenz als die Hauptwelle besitzt, und der dritte Filter (4) angeordnet ist, um aus dem empfangenen Signal eine Welle zu extrahieren, die zur Hauptwelle benachbart liegt und eine niedrigere Frequenz als die Hauptwelle besitzt;
eine Entzerrechnung (6), die auf die Hauptwelle vom ersten Filter (3) anspricht und beinhaltet: einen Teilintervallentzerrer, um eine Verzerrung zu entfernen, die durch die zur Hauptwelle benachbarten Wellen verursacht ist, und einen linearen entscheidungsstückgekoppelten Entzerrer, um eine Verzerrung zu entfernen, die durch ein frequenzausitivs Fa-
ding von dieser verursacht ist; eine Entzerrер-Steueleinrichtung (5), die auf die Hauptwelle vom ersten Filter (3) und die benachbarten Wellen vom zweiten Filter (2) und dem dritten Filter (4) anspricht, zum Vergleichen der Leistung der Hauptwelle mit derjenigen der benachbarten Wellen, um entweder den Teilintervallentzerrer oder den linearen entscheidungsrückgekoppelten Entzerrer auszuwählen.

2. Datenempfangssystem nach Anspruch 1, wobei die Entzerrer-Steueleinrichtung (5) die Leistung der Hauptwelle mit derjenigen der Summe der benachbarten Wellen vergleicht.

Revenndications

1. Système de réception de données comportant :

   des moyens formant filtres de réception comportant des premier, deuxième et troisième filtres (2, 3, 4), le premier filtre (3) étant conçu pour extraire une onde principale d'un signal reçu qui lui est appliqué, le deuxième filtre (2) étant conçu pour extraire du signal reçu une onde adjacente à l'onde principale et ayant une fréquence supérieure à celle de l'onde principale, et le troisième filtre (4) étant conçu pour extraire du signal reçu une onde adjacente à l'onde principale et ayant une fréquence inférieure à celle de l'onde principale, des moyens d'égalisation (6) réagissant à l'onde principale provenant du premier filtre (3) et comportant un égaliseur à intervalles fractionnaires pour supprimer de l'onde principale la distortion engendrée par les ondes adjacentes et un égaliseur récursif linéaire pour supprimer de celle-ci la distortion engendrée par un évanouissement sélectif en fréquence, des moyens de commande d'égalisation (5) réagissant à l'onde principale provenant du premier filtre (3) et aux ondes adjacentes provenant du deuxième filtre (2) et du troisième filtre (4) pour comparer la puissance de l'onde principale à celle des ondes adjacentes afin de sélectionner l'un ou l'autre dudit égaliseur à intervalles fractionnaires et dudit égaliseur récursif linéaire.

2. Système de réception de données selon la revendication 1, dans lequel les moyens de commande d'égalisation (5) comparant la puissance de l'onde principale à celle d'une somme des ondes adjacentes.
**FIG. 1** PRIOR ART

**FIG. 3**

[Diagram of system with labeled components and connections]