

Description

The invention relates to an FSK data receiver comprising a mixer stage for applying thereto a received FSK signal with a carrier signal f_c which is frequency-modulated by a data signal and has a given frequency swing Δf and a local oscillator signal produced by a voltage-controlled oscillator with a signal frequency f_L located within the band of the receiver, which relative to the carrier signal frequency f_c is frequency-shifted through a given value δf , and bandpass filter connected to the mixer stage, a detection circuit connected to the bandpass filter for recovering the data signal from the sum and difference-frequency signals $\Delta f \pm \delta f$ produced by the mixer stage, and an AFC control loop connected between the detection circuit and the voltage-controlled oscillator and comprising an integrator.

Such a data receiver is known from GB-A-1106913. This known receiver however is a carrier frequency modulated receiver and not an FSK data receiver.

It further is observed that United Kingdom patent Application No. 8132181 (PHN 32.819) discloses an FSK data receiver of the above mentioned kind with the only difference that the AFC loop comprises no integrator, in which receiver the sum and difference signal frequencies are filtered in separate filters after having passed the bandpass filter and are applied to a differential amplifier. This differential amplifier checks whether at that moment a high or a low signal level of the transmitted data signal is received.

The AFC control loop comprises a mixer stage to which a separate oscillator having a signal frequency equal to the frequency swing Δf is connected. The sum and difference signal frequencies applied to this mixer stage are down-transformed, whereafter the signal component having the given frequency value δf is obtained with the aid of a low-pass filter. This signal component is converted into a control voltage for the voltage-controlled oscillator with the aid of a frequency-voltage converter.

This receiver has the disadvantage that at least three sharp filters are used which, for production in accordance with integrated circuit techniques requires many external capacitors and a corresponding large number of connections. In addition, the AFC loop comprises an additional oscillator. In the receiver a controllable intermediate-frequency amplifier having a large dynamic range is required, which necessitates a large amount of current, which makes integration still more difficult. AM noise is not suppressed. Finally, the AFC loop used does not work satisfactory with small input signals which however still have an adequately large S/N ratio to enable adequate detection. The reason therefore is that for such small input signals the loop can lock onto several frequencies, more specifically onto noise signals.

In certain applications such as pagers very

severe requirements are imposed on the sensitivity, the selectivity and the consumed power. Thus, in England a sensitivity of 10 $\mu\text{V/m}$, a selectivity of -65 dB at ± 25 kHz and a power dissipation less than 6 mW is required for an aerial having a length of 3 cm in the frequency band for pagers from 148-152 MHz.

The invention has for its object to provide a novel concept of the FSK data receiver which obviates said disadvantages and has more specifically a high selectivity, combined with a wide pull in-range for the AFC control loop and which is easy to integrate.

According to the invention, the FSK data receiver described in the preamble, is characterized in that the receiver comprises means for increasing the amplitude of signals having frequencies located near the ends of the passband of the receiver over signals having intervening frequency signals and in that the integrator in the AFC control loop is coupled to the increasing means for generating a control signal for the voltage-controlled oscillator.

This has the advantage that only one filter must be provided, which can be a very narrow-band filter and that the AFC loop still has a wide pull-in range, is simple to integrate and enables a high signal-to-noise ratio.

According to a further embodiment, the FSK data receiver is characterized in that the increasing means comprise the bandpass filter and the detection circuit, that the characteristic of the bandpass filter has two peaks located around the signals having frequencies located near the ends of the passband, that the detection circuit comprises a limiter connected to the bandpass filter and a frequency-voltage converter having such a characteristic that the absolute value of the output voltage for the signals having frequencies located near the ends of the passband of the bandpass filter exceeds the value of the output voltage for the signals having intervening signal frequencies.

Acting thus said means are realized in a simple manner. According to a further embodiment, the FSK data receiver is characterized in that the increasing means comprise the detection circuit and a detector comprising a rectifier with a non-linear output, which detector is arranged in the AFC control loop, that the detection circuit comprises a frequency-voltage converter having such a characteristic that the absolute value of the output voltage for the signals having frequencies located near the ends of the passband of the bandpass filter exceeds the output voltage for the signals having intervening signal frequencies.

Realising said means is at least equally simple as for the above-mentioned realization.

Finally, a still further embodiment of the said means is characterized in that the increasing means comprise the detection circuit, that this detection circuit comprises a frequency-voltage converter having an amplitude and phase characteristic which is a non-linear function of the frequency, which characteristic is mirror-symmetrical relative to a reference point and the AFC

control loop comprises a rectifier arranged between the converter and the integrator.

The invention and its advantages will now be described in greater detail by way of example with reference to the embodiments shown in the accompanying Figures:

therein

Figure 1 shows a block circuit diagram of the FSK data receiver according to the invention;

Figures 2a—2d show characteristics of signals in the receiver of Figure 1 without the use of the measures according to the invention;

Figures 3a—3d show characteristics for signals in the receiver of Figure 1, when a special bandfilter is used;

Figures 4a—4d show characteristics for signals in the receiver of Figure 1 if a non-linear rectifier is used in the AFC loop;

Figures 5a—5d show characteristics for signals in the receiver of Figure 1 if both a special bandpass filter and a non-linear rectifier circuit are used; and

Figure 6 shows an example of the passband characteristic of the special bandpass filter according to the invention.

The FSK data receiver shown in Figure 1 is arranged for receiving a carrier signal which is frequency-modulated by a data signal, for example a data signal of 512 b/s frequency-modulating a carrier signal having a frequency f_c of 150 MHz with a frequency swing Δf of 4.5 kHz. Such an FSK signal having the frequencies $f_c \pm \Delta f$ and being determined by the logic signal values of the data signal is applied, after reception by the aerial 1 to a mixer circuit 2. A signal produced by a local oscillator 3 and having a frequency f_L is also applied to this mixer circuit. The frequency f_L is chosen such that it is frequency-shifted through a given small value δf relative to the carrier frequency f_c , so that it is well within the band of the receiver. δf has, for example, a value equal to 750 Hz.

The sum and difference-frequency signals $\Delta f + \delta f$ and $\Delta f - \delta f$ are formed in the mixer circuit 2. These signals are consequently mutually shifted through a frequency of $2\delta f$. Because of this frequency shift it is possible to recover the logic values of the data signal in a simple manner.

To that end these signals are applied to a detection circuit 5 after having been filtered in a band-pass filter 4. This detection circuit comprises a first limiter 6, a frequency-voltage converter 7 and a low-pass filter 8. The limiter 6 is used *inter alia* for suppressing AM noise. The frequency-voltage converter is, for example, a Forter-Seeley discriminator as is described in *inter alia* the article "Forter-Seeley Discriminator" by C. G. Mayo and J. W. Head, published in Electron. Radio Egnre. February 1958. Such a discriminator has an amplitude and phase characteristic which is a linear function of the frequency. If the reference point of the characteristic is chosen at the frequency Δf , the points on the characteristic curve for the frequencies are located plus and minus δf symmetrically relative

to this reference point and at these frequencies $+\delta f$ and $-\delta f$ equal but opposite output voltages compared with the voltage level determined by the reference points are supplied.

These output voltages are filtered by the low-pass filter 8 with a frequency at the breakpoint of approximately 250 Hz for a 512 b/s data signal. The data signal thus recovered is applied to an output 9 of the receiver.

In addition, the data receiver comprises an AFC control loop 10 connected between the output 9 and a control input 11 of the voltage-controlled oscillator 3, for having the voltage-controlled oscillator vary with the frequency drift of the input signal. This control loop 10 comprises a detector 12, a reference voltage source 13, a differential amplifier 14, an integrator 16 and optionally a second limiter 17. A signal produced by the detector 12 is applied together with the reference voltage produced by the reference voltage source 13 to the differential amplifier 14, which has a current output 15. In the differential amplifier the voltage difference between the input signals is determined and converted into an output current I_{AFC} proportional thereto. This output current I_{AFC} is applied to the integrator 16. The output voltage of integrator 16 is applied as a control signal to the control input 11 of the voltage-controlled oscillator 3, via the optional second limiter 17.

In Figure 2a, the current I_{AFC} supplied by the differential amplifier 14 is shown as a function of the frequency difference between the frequency of a received signal and the signal frequency f_L produced by the voltage-controlled oscillator 3. Let it be assumed that the band-pass filter 4 has a straight transmission characteristic as shown in Figure 2b and that the second detector 12 is a rectifier having a linear rectifier characteristic denoted by $|V|$ in Figure 2c. In this Figure, the solid line applies to small input signals and the broken-line portion indicates the deviation of the solid line for large input signals.

The zero point of the frequency axis is located at the reference frequency Δf determined by the frequency-voltage converter, so that δf is plotted along the frequency axis.

The zero-crossing point of the current axis is determined by the magnitude of the desired value of the frequency δf , to which normally the voltage-controlled oscillator 3 (VCO) above or below the carrier frequency is tuned. In this embodiment a tuning above the carrier frequency, more specifically +750 Hz is opted for. As will be obvious from this Figure, the current I_{AFC} produced is negative for mixed frequencies located between -750 Hz and +750 Hz and the current I_{AFC} is positive for small signals for mixed frequencies between +750 Hz and approximately 1200 Hz. The voltage V_{AFC} produced by the integrator 16 in response to these currents controls the voltage-controlled oscillator 3 such that the frequency of the oscillator is down-controlled for a negative control voltage and is up-controlled for a positive control voltage. As a result thereof the frequency of the oscillator 3 is always adjusted to the

desired value of δf . The integrator 16 ensures that no residual error remains.

In order to realise a largest possible signal-to-noise ratio (S/N) and a best possible channel separation, the bandwidth of the bandfilter 4 is chosen as low as possible. This has for its consequence that if no transmitted signal is received by the receiver and consequently only noise is received within the band, the receiving level is so low that the current I_{AFC} applied to the integrator 6 is below the reference level and is consequently negative, as is shown in Figure 2d. Moreover, in the example shown in Figure 2a this occurs *inter alia* when δf is frequency-shifted through more than 1250 Hz in the positive direction relative to Δf . In both cases the frequency of the VCO 3 is adjusted to higher values of δf and the AFC control loop is shifted to its highest frequency value. Consequently, the control loop cannot be pulled in any more by a transmitted signal as the loop is outside the pull-in range.

To obviate this, without widening the passband of the filter so without decreasing the signal-to-noise ratio, a bandpass filter 4 is used whose transmission characteristic has two peaks located near the ends of the passband of the filter as is shown in Figure 3b. Because of these two peaks in the passband the amplitudes of signals having frequencies located near the ends of the passband are larger than the amplitudes of signals having intervening frequencies, more specifically compared with signals having frequencies located near $\delta f=0$.

These signals are limited in the hard limiter 6. As is known, a limiter has the property to benefit signals having the largest amplitude at the cost of signals having a smaller amplitude. The ratio in which this occurs is the so-called "capture ratio". This implicates that after having passed the limiter 6 the ratio of the number of frequency components located at the ends of the passband relative to the frequency components in the centre of the band ($\delta f=0$) is increased with respect to the ratio of the signals applied thereto.

In the frequency-to-voltage converter 7 frequencies located near the centre of the band are converted into a voltage having a much smaller amplitude than frequencies located near the ends. After rectification in the detector 12 the average value of the current I_{AFC} applied to the integrator 16 has increased, because of the joint action of the special bandpass filter 4, the limiter 6 and the frequency-voltage converter 7 relative to the average value for a bandpass filter having a flat transmission characteristic.

A bandpass filter suitable for this purpose is realized by means of the cascade-arrangement of two differently adjusted Sallen and Key filters, whose transmission characteristics are shown in Figure 6. As this Figure shows the lowest point between two peaks of the transmission characteristic is located at a chosen Δf of 4.5 kHz, and the peaks of a δf of 750 Hz chosen associated therewith are selected at 3.75 and 5.25 kHz. The difference in level at 4.5 kHz and at 3.75 and 5.25

kHz, respectively is ≈ 3 dB. The higher average value of the current I_{AFC} obtained with the aid of this filter and applied to the integrator 16 is shown in the Figures 3a and 3b, both for the case that the oscillator frequency has such a value that the signal mixed with a received signal is located outside the band, so for a δf larger than approximately 1200 Hz, and for the case in which there is no input signal and only white noise is received.

As these Figures clearly show the average value of the signals has increased, more specifically to such an extent that the current I_{AFC} applied to the integrator 6 is located above the zero level for both the above-mentioned cases. Consequently, the integrator 16 applies a positive control voltage V_{AFC} to the oscillator 3 in response to which the frequency of the oscillator is adjusted downwards.

If no input signal is present, the oscillator will be controlled to the desired value of δf , in this case +750 Hz, and will be maintained without residual error. If no input signal is present, then the frequency of the oscillator is controlled down to such an extent that the oscillator clips, so that when off-set occurs between the transmitting frequency and the frequency of the VCO, for example due to drift, the desired signal is always located within the passband of the filter. The pull-in range of the AFC-loop is in principle extended upwards to infinity because of the use of the special bandpass filter 4, without the signal-to-noise level of the receiver being reduced.

When the oscillator 3 has a control range which in the negative direction passes the frequency of the unstable setting point at -750 Hz, the limiter 17 shown in Figure 1 as a broken-line block is indispensable. This limiter limits the control voltage V_{AFC} produced by the integrator 16 to such a value that the maximum frequency offset between the oscillator 3 and the signal to be received can never become larger than -750 Hz, for example -720 Hz. In this way, a perfect operation of the AFC-loop is ensured in all circumstances without loss in sensitivity.

The width of the pull-in range of the AFC-loop after said measures have been applied is only shown in the Figures 5a and 5d, denoted by L. This pull-in range also holds, however, for the Figures 3a, 3d, 4a and 4b.

Instead of using a special bandpass filter 4, an increase in the average value of the current I_{AFC} applied to the integrator 6 on receipt of noise can alternatively be affected by using other measures, more specifically by using in the detector 12 a rectifier having a non-linear rectification characteristic for example a rectifier having a square-law characteristic. This is shown in Figure 4c by means of $|V^2|$.

As has already been described in the foregoing, the frequency-voltage converter 7 produces signals with an amplitude which increases and decreases linearly from $\delta f=0$ to the frequency of the signal. As these signals are rectified with a square-law characteristic in the detector 12, the amplitude of large-amplitude signals are given

preference over signals having a small amplitude. As a result thereof, the current I_{AFC} applied to the integrator 6 has the value shown in Figure 4a as a function of the frequency δf when an input signal is received and has the characteristic shown in Figure 5d when only white noise is received. By giving the higher signal frequencies the advantage due to the joint operation of the frequency-voltage converter 7 and the detector 12, an increase in the average value of the current I_{AFC} is again realized without deteriorating the signal-to-noise ratio. The signal value on receipt of white noise is consequently again located above the zero level and the pull-in range for positive δf is in principle again increased to plus infinity.

Instead of a square-law rectification characteristic it is alternatively possible to use detectors having a higher order rectification characteristic, whereby said effect is still further increased.

It is, however, alternatively possible to use a rectifier having a linear characteristic and to use a frequency-voltage converter 7 having a non-linear, for example a square-law characteristic, mirror-inverted around the reference point Δf , but together with a bandpass filter 4 having a flat transmission characteristic. The results shown in the Figures 4a and 4d are also obtained with a frequency-voltage converter 7 having a square-law characteristic.

It will be obvious that all combinations from the set given by a specific bandpass filter, a non-linear characteristic of the frequency-voltage converter and a non-linear rectification characteristic of the detector 12 can be applied. Thus Figures 5a and 5d show the result of a receiver comprising the special bandpass filter 4 (Figure 5b) and a square-law rectification characteristic (Figure 5c) of the detector 12. The higher average value of the current I_{AFC} applied to the integrator 6 obtained by the joint operation is clearly shown in these Figures as is also the increase of the noise level near $\delta f=0$. However, because of its comparatively low value this last increase is not objectionable. The advantage of the large positive current value of I_{AFC} for noise is *inter alia* a shorter settling time of the AFC-loop after switch-on of the receiver.

The additional space obtained may, however, alternatively be used to increase the selectivity of the receiver by somewhat reducing the bandwidth of the bandpass filter.

Because of the fact that the receiver has *inter alia* only one single filter it can be easily produced in integrated circuit technique.

Claims

1. An FSK data receiver comprising a mixer stage (2) for applying thereto a received FSK signal with a carrier signal f_c which is frequency-modulated by a data signal and has a given frequency swing Δf and a local oscillator signal produced by a voltage-controlled oscillator (3) with a signal frequency f_l located within the band of the receiver, which relative to the carrier signal frequency f_c is frequency-shifted through a given

value δf , a bandpass filter (4) connected to the mixer stage; a detection circuit (5) connected to the bandpass filter for recovering the data signal from the sum and differences frequency signals $\Delta f \pm \delta f$ produced by the mixer stage and an AFC control loop (10) connected between the detection circuit (5) and the voltage-controlled oscillator (3) and comprising an integrator (16) for generating a control signal for the voltage-controlled oscillator, characterized in that the receiver comprises means for increasing the amplitude of signals having frequencies located near the ends of the passband of the receiver over signals having intervening frequency signals and in that the integrator (16) in the AFC control loop is coupled to the increasing means.

2. An FSK data receiver as claimed in Claim 1, characterized in that the increasing means comprise the bandpass filter (4) and the detection circuit (5), the characteristic of the bandpass filter having two peaks located around the signals having frequencies located near the ends of the passband, the detection circuit comprising a limiter (6) connected to the bandpass filter (4) and a frequency-voltage converter (7) having such a characteristic that the absolute value of the output voltage for the signals having frequencies located near the ends of the passband of the bandpass filter exceeds the value of the output voltage for the signals having intervening signal frequencies.

3. An FSK data receiver as claimed in Claim 1, characterized in that the increasing means comprise the detection circuit (5) and a detector comprising a rectifier (12) with a non-linear output, which detector is arranged in the AFC control loop, the detection circuit comprising a frequency-voltage converter (7) having such a characteristic that the absolute value of the output for the signals having frequencies located near the ends of the passband of the bandpass filter exceeds the output voltage for the signals having intervening signal frequencies.

4. An FSK data receiver as claimed in Claim 1, characterized in that the increasing means comprise the detection circuit (5), this detection circuit comprising a frequency-voltage converter (7) having an amplitude and phase characteristic which is a non-linear function of the frequency and which is mirror-symmetrical relative to a reference point; the AFC control loop (10) comprising a rectifier (12) arranged between the frequency voltage converter (7) and the integrator (16).

5. An FSK data receiver as claimed in Claim 2 or 3, characterized in that the frequency-voltage converter (7) has an amplitude and phase characteristic which is a linear function of the frequency and whose reference point is located at the frequency Δf and the AFC control loop comprises a rectifier (12) included between the frequency-voltage converter and the integrator.

6. An FSK data receiver as claimed in Claim 5, characterized in that the AFC control loop 10 comprises a reference voltage source and a differential amplifier (14) having a current output,

preference over signals having a small amplitude. As a result thereof, the current I_{AFC} applied to the integrator 6 has the value shown in Figure 4a as a function of the frequency δf when an input signal is received and has the characteristic shown in Figure 5d when only white noise is received. By giving the higher signal frequencies the advantage due to the joint operation of the frequency-voltage converter 7 and the detector 12, an increase in the average value of the current I_{AFC} is again realized without deteriorating the signal-to-noise ratio. The signal value on receipt of white noise is consequently again located above the zero level and the pull-in range for positive δf is in principle again increased to plus infinity.

Instead of a square-law rectification characteristic it is alternatively possible to use detectors having a higher order rectification characteristic, whereby said effect is still further increased.

It is, however, alternatively possible to use a rectifier having a linear characteristic and to use a frequency-voltage converter 7 having a non-linear, for example a square-law characteristic, mirror-inverted around the reference point Δf , but together with a bandpass filter 4 having a flat transmission characteristic. The results shown in the Figures 4a and 4d are also obtained with a frequency-voltage converter 7 having a square-law characteristic.

It will be obvious that all combinations from the set given by a specific bandpass filter, a non-linear characteristic of the frequency-voltage converter and a non-linear rectification characteristic of the detector 12 can be applied. Thus Figures 5a and 5d show the result of a receiver comprising the special bandpass filter 4 (Figure 5b) and a square-law rectification characteristic (Figure 5c) of the detector 12. The higher average value of the current I_{AFC} applied to the integrator 6 obtained by the joint operation is clearly shown in these Figures as is also the increase of the noise level near $\delta f = 0$. However, because of its comparatively low value this last increase is not objectionable. The advantage of the large positive current value of I_{AFC} for noise is *inter alia* a shorter settling time of the AFC-loop after switch-on of the receiver.

The additional space obtained may, however, alternatively be used to increase the selectivity of the receiver by somewhat reducing the bandwidth of the bandpass filter.

Because of the fact that the receiver has *inter alia* only one single filter it can be easily produced in integrated circuit technique.

Claims

1. An FSK data receiver comprising a mixer stage (2) for applying thereto a received FSK signal with a carrier signal f_c which is frequency-modulated by a data signal and has a given frequency swing Δf and a local oscillator signal produced by a voltage-controlled oscillator (3) with a signal frequency f_L located within the band of the receiver, which relative to the carrier signal frequency f_c is frequency-shifted through a given

value δf , a bandpass filter (4) connected to the mixer stage; a detection circuit (5) connected to the bandpass filter for recovering the data signal from the sum and differences frequency signals $\Delta f \pm \delta f$ produced by the mixer stage and an AFC control loop (10) connected between the detection circuit (5) and the voltage-controlled oscillator (3) and comprising an integrator (16) for generating a control signal for the voltage-controlled oscillator, characterized in that the receiver comprises means for increasing the amplitude of signals having frequencies located near the ends of the passband of the receiver over signals having intervening frequency signals and in that the integrator (16) in the AFC control loop is coupled to the increasing means.

2. An FSK data receiver as claimed in Claim 1, characterized in that the increasing means comprise the bandpass filter (4) and the detection circuit (5), the characteristic of the bandpass filter having two peaks located around the signals having frequencies located near the ends of the passband, the detection circuit comprising a limiter (6) connected to the bandpass filter (4) and a frequency-voltage converter (7) having such a characteristic that the absolute value of the output voltage for the signals having frequencies located near the ends of the passband of the bandpass filter exceeds the value of the output voltage for the signals having intervening signal frequencies.

3. An FSK data receiver as claimed in Claim 1, characterized in that the increasing means comprise the detection circuit (5) and a detector comprising a rectifier (12) with a non-linear output, which detector is arranged in the AFC control loop, the detection circuit comprising a frequency-voltage converter (7) having such a characteristic that the absolute value of the output for the signals having frequencies located near the ends of the passband of the bandpass filter exceeds the output voltage for the signals having intervening signal frequencies.

4. An FSK data receiver as claimed in Claim 1, characterized in that the increasing means comprise the detection circuit (5), this detection circuit comprising a frequency-voltage converter (7) having an amplitude and phase characteristic which is a non-linear function of the frequency and which is mirror-symmetrical relative to a reference point; the AFC control loop (10) comprising a rectifier (12) arranged between the frequency voltage converter (7) and the integrator (16).

5. An FSK data receiver as claimed in Claim 2 or 3, characterized in that the frequency-voltage converter (7) has an amplitude and phase characteristic which is a linear function of the frequency and whose reference point is located at the frequency Δf and the AFC control loop comprises a rectifier (12) included between the frequency-voltage converter and the integrator.

6. An FSK data receiver as claimed in Claim 5, characterized in that the AFC control loop 10 comprises a reference voltage source and a differential amplifier (14) having a current output,



the output being connected to the integrator (16), and in that the reference voltage source (13) and the rectifier (12) are connected to inputs of the differential amplifier (14).

7. An FSK data receiver as claimed in Claim 1, characterized in that the AFC control loop comprises a second limiter (17) connected between the integrator (16) and the voltage-controlled oscillator (13).

Patentansprüche

1. FSK-Datenempfänger mit einer Mischstufe (2) zum Zuführen zu derselben eines empfangenen FSK-Signals mit einem durch ein Datensignal frequenzmodulierten Trägersignal f_c mit einem bestimmten Frequenzhub Δf sowie eines von einem spannungsgesteuerten Oszillator (3) erzeugten Ortsoszillatorsignals mit einer innerhalb des Bandes des Empfängers liegenden Signalfrequenz f_L , die gegenüber der Trägersignalfrequenz f_c über einen bestimmten Wert δf frequenzverschoben ist, mit einem mit der Mischstufe verbundenen Bandpaßfilter (4); einem mit dem Bandpaßfilter verbundenen Detektionskreis (5) zum Zurückgewinnen des Datensignals aus den von der Mischstufe erzeugten Summen- und den Differenzfrequenzsignalen $\Delta f \pm \delta f$ sowie mit einer zwischen dem Detektionskreis (5) und dem spannungsgesteuerten Oszillator (3) vorgesehenen AFR-Regelschleife (10), die einen Integrator (16) aufweist zum Erzeugen eines Regelsignals für den spannungsgesteuerten Oszillator, dadurch gekennzeichnet, daß der Empfänger Mittel aufweist zum Erhöhen der Amplitude von Signalen mit Frequenzen in der Nähe der Enden des Durchlaßbandes des Empfängers über Signale mit zwischen denselben liegenden Signalfrequenzen und daß der Integrator (16) in der AFR-Regelschleife mit den Steigerungsmitteln gekoppelt ist.

2. FSK-Datenempfänger nach Anspruch 1, dadurch gekennzeichnet, daß die Steigerungsmittel das Bandpaßfilter (4) und den Detektionskreis (5) aufweist, wobei die Kennlinie des Bandpaßfilters zwei Spitzen aufweist, die um die Signale herum liegen, deren Frequenzen in der Nähe der Enden des Durchlaßbandes liegen, wobei der Detektionskreis einen mit dem Bandpaßfilter (4) verbundenen Begrenzer (6) aufweist, sowie einen Frequenz-Spannungswandler (7) mit einer derartigen Kennlinie, daß der Absolutwert der Ausgangsspannung für die Signale mit Frequenzen in der Nähe der Enden des Durchlaßbandes des Bandpaßfilters den Wert der Ausgangsspannung für die Signale mit zwischen denselben liegenden Signalfrequenzen übersteigt.

3. FSK-Datenempfänger nach Anspruch 1, dadurch gekennzeichnet, daß die Steigerungsmittel den Detektionskreis (5) und einen in der AFR-Regelschleife vorgesehenen Detektor mit einem Gleichrichter (12) mit einem nicht-linearen Ausgang, wobei der Detektionskreis einen Frequenz-Spannungswandler (7) mit einer derartigen Kennlinie aufweist, daß der Absolutwert der Ausgangsspannung für die Signale mit Frequenzen in

der Nähe der Enden des Durchlaßbandes des Bandpaßfilters die Ausgangsspannung für die Signale mit zwischen denselben liegenden Signalfrequenzen übersteigt.

4. FSK-Datenempfänger nach Anspruch 1, dadurch gekennzeichnet, daß die Steigerungsmittel den Detektionskreis (5) aufweisen, der einen Frequenz-Spannungswandler (7) aufweist mit einer Amplituden und Phasenkennlinie, die eine nicht-lineare Funktion der Frequenz ist und die gegenüber einem Bezugspunkt spiegelsymmetrisch ist; wobei die AFR-Regelschleife (10) einen zwischen dem Frequenz-Spannungswandler (7) und dem Integrator (16) vorgesehenen Gleichrichter (12) aufweist.

5. FSK-Datenempfänger nach Anspruch 2 oder 3, dadurch gekennzeichnet, daß der Frequenz-Spannungswandler (7) eine Amplitude- und Phasenkennlinie aufweist, die eine lineare Funktion der Frequenz ist und deren Bezugspunkt bei der Frequenz Δf liegt und wobei die AFR-Regelschleife einen Gleichrichter (12) zwischen dem Frequenz-Spannungswandler und dem Integrator aufweist.

6. FSK-Datenempfänger nach Anspruch 5, dadurch gekennzeichnet, daß die AFR-Regelschleife (10) eine Bezugsspannungsquelle und einen Differenzverstärker (14) mit einem Stromausgang aufweist, wobei dieser Ausgang mit dem Integrator (16) verbunden ist, und daß die Bezugsspannungsquelle (13) und der Gleichrichter (12) mit Eingängen des Differenzverstärkers (14) verbunden ist.

7. FSK-Datenempfänger nach Anspruch 1, dadurch gekennzeichnet, daß die AFR-Regelschleife einen zwischen dem Integrator (16) und dem spannungsgesteuerten Oszillator (13) vorgesehenen zweiten Begrenzer (17) aufweist.

Revendications

1. Récepteur de données MDF comprenant un étage mélangeur (2) pour y appliquer un signal MDF reçu avec un signal porteur f_c qui est modulé en fréquence par un signal de données et présente une excursion de fréquence donnée Δf et un signal d'oscillateur local produit par un oscillateur commandé en tension (3) présentant une fréquence de signal f_L située dans la bande du récepteur, qui, par rapport à la fréquence de signal porteur f_c est déplacée en fréquence d'une valeur donnée δf , et un filtre passe-bande (4) connecté à l'étage mélangeur, un circuit de détection (5) connecté au filtre passe-bande pour récupérer le signal de données des signaux de fréquence de somme et de différence $\Delta f \pm \delta f$ produits par l'étage mélangeur et une boucle de contrôle CAF (10) connectée entre le circuit de détection (5) et l'oscillateur commandé en tension (3) et comprenant un intégrateur (16) pour produire un signal de commande pour l'oscillateur commandé en tension, caractérisé en ce qu'il comprend des moyens pour augmenter l'amplitude de signaux ayant des fréquences proches des extrémités de la bande passante du récepteur par



rapport à des signaux comprenant des signaux de fréquence intermédiaire et en ce que l'intégrateur (16) dans la boucle de contrôle CAF est couplé aux moyens d'augmentation.

2. Récepteur de données MDF suivant la revendication 1, caractérisé en ce que les moyens d'augmentation comprennent le filtre passe-bande (4) et le circuit de détection (5), la caractéristique du filtre passe-bande présentant deux crêtes proches des signaux ayant des fréquences situées près des extrémités de la bande passante, le circuit de détection comprenant un limiteur (6) connecté au filtre passe-bande (4) et un convertisseur de fréquence-tension (7) présentant une caractéristique telle que la valeur absolue de la tension de sortie pour les signaux ayant des fréquences proches des extrémités de la bande passante du filtre passe-bande excède la valeur de la tension de sortie pour les signaux ayant des fréquences de signaux intermédiaires.

3. Récepteur de données MDF suivant la revendication 1, caractérisé en ce que les moyens d'augmentation comprennent le circuit de détection (5) et un détecteur comprenant un redresseur (12) à sortie non linéaire, ce détecteur étant disposé dans la boucle de contrôle CAF, le circuit de détection comprenant un convertisseur de fréquence-tension (7) présentant une caractéristique telle que la valeur absolue de la sortie pour les signaux ayant des fréquences proches des extrémités de la bande passante du filtre passe-bande excède la tension de sortie pour les signaux ayant des fréquences de signaux intermédiaires.

4. Récepteur de données MDF suivant la reven-

dication 1, caractérisé en ce que les moyens d'augmentation comprennent le circuit de détection (5), ce circuit de détection comprenant un convertisseur de fréquence-tension (7) présentant une caractéristique de phase et d'amplitude qui est une fonction non linéaire de la fréquence et présente une symétrie spéculaire par rapport à un point de référence, la boucle de commande CAF (10) comprenant un redresseur (12) disposé entre le convertisseur de fréquence-tension (7) et l'intégrateur (16).

5. Récepteur de données MDF suivant la revendication 2 ou 3, caractérisé en ce que le convertisseur de fréquence-tension (7) présente une caractéristique d'amplitude et de phase qui est une fonction linéaire de la fréquence et dont le point de référence est situé à la fréquence Δf et la boucle de commande CAF comprend un redresseur (12) incorporé entre le convertisseur de fréquence-tension et l'intégrateur.

6. Récepteur de données MDF suivant la revendication 5, caractérisé en ce que la boucle de commande CAF (10) comprend une source de tension de référence et un amplificateur différentiel (14) comportant une sortie de courant, la sortie étant connectée à l'intégrateur (16), et en ce que la source de tension de référence (13) et le redresseur (12) sont connectés à des entrées de l'amplificateur différentiel (14).

7. Récepteur de données MDF suivant la revendication 1, caractérisé en ce que la boucle de commande CAF comprend un second limiteur (17) connecté entre l'intégrateur (16) et l'oscillateur commandé en tension (3).



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