

Method for the processing and reproduction of received digitally coded audio data and a radio broadcast receiver for the reception of digitally coded sound broadcasting data (DAB)

With digital transmission media e.g. digital sound broadcasting (DAB, "DAB" is a trade mark of the TELEFUNKEN Fernseh und Rundfunk GmbH), there occurs an abrupt interruption of the reception at the edge of a coverage area i.e. when the transmission channel is at the limit of its capability. This also happens, in particular, when a high performance code is used for error correction. A transition from very good reception to no reception at all can thereby occur within a 1 dB reduction of the received voltage.

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This behaviour is not desired since the user is not warned in good time to switch to another transmitter. On the contrary, upon the cessation of the reproduction, he will actually falsely assume that his receiving device has a fault or is defective such as having e.g. a destroyed IC, loose contacts, a broken loud speaker or the like.

The problem of not switching over to another transmitter in good time can of course generally be resolved with the aid of RDS for example but not in the case of a short term failure of reception such as can happen when driving under bridges or suchlike things.

The reception quality of VHF-FM is of course poorer at the edge of a coverage area of a transmitter but, from the point of view of reception behaviour, it is appreciably better since the transition from very good reception to impossible reception takes place over a range of the received voltage of up to 30 dB i.e. smoothly from good to bad over much greater distances.

For digital transmission systems, the suggestion is repeatedly made of inducing a so-called sliding worsening of reproduction - also known as "graceful degradation". From the Forum Report "Innovatives Europa", Report, Frank Müller-Römer: "Digital Audio Broadcast (DAB)", Bonn-Bad Godesberg, 8th March 1990, the general

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problem is known, of smoothly switching over from stereo to mono - in the same way as for VHF-FM - rather than having an abrupt interruption of the DAB reception in the event of reception field strengths becoming weaker and of worsening reception conditions. In adverse circumstances, one can assume that, during the switch-over from stereo to mono, the listener will not even notice the switch-over since the listening conditions are not always appropriate therefor or because the currently received transmission is in any case being transmitted in mono (e.g. a news broadcaster).

Moreover, the concept of the "graceful degradation" of a digital audio transmission system is known from J. Audio Engineering Reports Soc., Vol 36, No 1/2, 1988 January/February. There, the advantage of the "graceful degradation" is described for an audio reproduction where the audio signal is transmitted over channels having a large range of bandwidth. However, the measures indicated there are not suitable for providing a simple, cost effective and, for the listener, a permanently satisfactory solution of the problem described since, amongst other things, the outlay is quite considerable for a plurality of differently effective error correcting methods. It has also been shown that although a broadening of the cross-over region can indeed be achieved, this only amounts to little more than a few dB.

Since, in addition, the quality of the transmission path or of the reception frequently changes by large amounts on digital paths and especially for mobile reception, there arises a greatly fluctuating "graceful degradation" which does not correspond to the average behaviour of the transmission channel.

The object of the invention is to avoid, using simple means, an abrupt interruption of the reception or of the audio reproduction in the event of reception field strengths becoming weaker and of worsening reception conditions.

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Furthermore, the object of the invention is to construct a radio broadcast receiver such that the aforesaid disadvantages do not occur upon reception of a digitally coded audio signal.

In accordance with the invention, the object is achieved by a method for the processing and reproduction of digitally coded audio data which has the features in accordance with claim 1. Advantageous developments of the method are specified in the appendant claims 2 to 6 and can also be gathered from the following description.

The further object of the invention is achieved, in accordance with the invention, by a radio broadcast receiver having the features in accordance with claim 7.

The invention is based upon the following consideration: One measures the reception quality e.g. the bit error rate, of the received audio data using suitable means e.g. a bit error rate measuring device. The measured error rate or bit error rate or reception quality is a criterion for the transmission quality factor of the transmission channel or of the received audio data e.g. the quality factor is the reciprocal of the error rate. Furthermore, one defines a threshold value for the error rate (or transmission quality factor) which lies below (above) the error rate (or quality factor) at which the abrupt interruption of the reproduction or of the reception or of the transmission occurs.

Upon exceeding (falling below) the predetermined threshold value of the error rate (transmission quality factor), there occurs an alteration, which is readily perceptible for the user, of at least one reproduction parameter or of the quality of reproduction. This can happen during the reproduction in the form, for example, of an addition of noise or of a characteristic tone to the audio reproduction signal or else can be achieved by a reduction of the volume level of the reproduced signal or by a displacement of the transmission limiting frequency to low audible frequencies. The latter is achieved in that a digital low pass filter is arranged in the signal path of



the audio signals to the reproduction device and is activated whereby the limiting frequency or the limiting of the low pass filter is reduced, preferably, variably or smoothly, upon the previously set threshold value of the error rate being exceeded and thus alters the reproduction frequency spectrum in a perceptible manner. If the measured error rate lies below the threshold value, the low pass filter does not have a varying effect upon the reproduction.

Thus, there is carried out an artificial "graceful degradation" whereby the reproduction signal is artificially altered in dependence on the quality of transmission or reception when there is a drop below a preset threshold value for the quality or quality factor of transmission or reception.

By means of the previously described simple measures, the user is made aware of an expected abrupt interruption of the reception in good time. For example, if a noise signal is added to the reproduction signal, the intended worsening of reproduction corresponds to what a listener of the VHF-FM reception is already used to, such as, for example, the increased noise when driving under bridges, when travelling through tunnels or at the edge of a signal propagation area, etc.

It is useful, to be able to variably set the threshold value. This is especially advantageous for mobile radio broadcast reception if the threshold value is altered in dependence on the speed of travel since even an average error rate can still mean a good reception or reproduction quality at high speed.

Preferably, the error rate or the quality factor criterion derived therefrom is subjected to a low pass filtering so that the artificial alteration in the reproduction device can occur more on the basis of the average channel quality. The low pass filter may then also have different time constants for its rise and/or fall.



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The invention will be explained more fully hereinafter by means of one possible embodiment which is illustrated in the drawing.

The Figure shows a DAB mobile receiver 1 having a receiving antenna 2, a HF-IF section 3 connected therewith, an IF signal processor 4a, an A/D converter 4b integrated therein, a DAB source decoder 5, an audio signal processor 6, an AF amplifying stage 7a having a D/A converter 7b contained therein, a loud speaker 8 and a micro-processor 9 which contains a measuring device 9a (BER - Bit-ERROR-Rate) for the determination of the bit error rate of a digital signal.

In correspondence with the Figure, the digital signal processing specific to DAB is accomplished by the IF signal processor 4a, DAB source decoder 5 and audio signal processor 6 whereby these circuit sections are normally constructed as highly integrated circuits. The audio signal processor 6 takes over the audio functions such as tone control, volume control, mixing, balance etc., which are realised in present day receivers in analogue circuit technique. The IF signal processor 4a serves for extracting, from the signal which is delivered by the HF/IF section 3 that is conventionally constructed, the data stream contained therein.

For the control of the receiver, there serves the micro-processor 9, to which a value for the speed of travel is supplied via an input 10, to which the whole data stream or a part thereof is supplied via an input 11, to which data from the source decoder is supplied via an input 12, and to which input values from a (not illustrated) control device are supplied via further inputs 13 and 14. The micro-processor is connected to a control input 17 of the audio signal processor 6 via an output 15 and a control lead 16. Moreover, the micro-processor contains a bit error rate measuring device 9a which determines the error rate of the received signals from the data stream supplied via the input 11. A threshold value for the error rate, which is altered in dependence on the speed of travel, is stored in the micro-processor. The current error rate or the threshold value

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or a difference of the two values may be constantly indicated on a display.

In dependence upon whether the measured error rate exceeds the threshold value of the error rate, the audio signal processor is controlled in such a way that a noise, which is easily perceptible by the listener, is added to the AF signal that is to be amplified. If the reception is abruptly interrupted, then only a noise or a characteristic signal which is generated by the audio signal processor (either constantly or occasionally) is to be heard from the loud speaker 8. The perceptible, artificial alteration of the audio signal increases smoothly or in steps, each time, in dependence upon how much the threshold value of the error rate is exceeded. To this end, the measured value of the error rate is subjected to a low pass filtering in the micro-processor so that the artificial alteration occurs more on the basis of the average channel quality. The low pass filter has different and/or variable time constants for the rises and falls. The threshold value is altered, preferably raised, with increasing speed of travel.

Moreover, in dependence upon the rise of the measured error rate, various switch-overs of the HF/IF section 3 are effected via a control lead 18 by the micro-processor 9. If the error rate increases in a jumplike manner from a value below the set error rate threshold value (i.e. good reception) to a value far above the threshold value (abrupt interruption of the reception), merely a noise or characteristic signal is given at the outputs of the signal processor as previously described.

If, however, the increase in the error rate proceeds slowly and smoothly up to the complete interruption of the reception, then, upon exceeding the error rate threshold value, a reception frequency from an acceptably receivable transmitter having the same or another programme, to which the HF/IF section 3 is newly tuned after the abrupt interruption of reception, is searched for in the micro-processor. Thereby, it is ensured that, even after the interruption of the reception, when no data regarding another transmitter can be received any longer, the radio



broadcast receiver switches automatically to an acceptably receivable transmitter preferably having the same programme. A slow and smooth increase of the error rate is an indication that the coverage area of a transmitter is being left e.g. while driving, a jumplike increase of the error rate means that one is driving below or through a bridge or tunnel etc, whereby the HF/IF section 3 remains tuned to the same transmitter.

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Claims



1. Method for the processing and/or reproduction of received digitally coded audio data e.g. digital sound broadcasting data (DAB), wherein the reception or transmission quality e.g. the bit error rate, of the audio data is measured by suitable means, wherein a threshold value for the quality factor of the reception or transmission quality is determined and, upon falling below the threshold value, there occurs an alteration, which is perceptible by the user, of a reproduction quality parameter and/or a noticeable display.
2. Method in accordance with Claim 1, characterised in that, upon falling below the determined reception quality, a noise signal and/or a characterising signal e.g. a characteristic tone is added to the reproduction signal.
3. Method in accordance with Claim 1, characterised in that, upon falling below the determined reception quality, the reproduction signal is low pass filtered and/or the volume level of the reproduction signal is reduced.
4. Method in accordance with any of the Claims 1 to 3, characterised in that, the measured error rate is low pass filtered.
5. Method in accordance with any of the Claims 1 to 3, characterised in that, for mobile reception, the threshold value for the reception or transmission quality is altered in dependence on the speed of travel.
6. Method in accordance with any one of the preceding Claims, characterised in that, the quality factor of the reception or transmission quality corresponds to the reciprocal of the error rate.
7. Radio broadcast receiver for the reception of digitally coded sound broadcasting data (DAB) including a measuring device for measuring the reception quality e.g. a bit error rate measuring



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device, a control device for controlling the reproduction of the sound broadcasting data, wherein a reception quality threshold value is defined in the control device and, upon the measured reception quality falling below the threshold value, the control device alters the reception quality and/or the reproduction signals in a perceptible manner.

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Abstract

1. Method for the processing and reproduction of received digitally coded audio data and a radio broadcast receiver for the reception of digitally coded sound broadcasting data (DAB)
 - 2.1 With digital transmission media e.g. digital sound broadcasting (DAB), there occurs an abrupt interruption of the reception at the edge of a coverage area i.e. when the transmission channel is at the limit of its capability. For digital transmission systems, the suggestion is repeatedly made of inducing a so-called sliding worsening of reproduction - "graceful degradation".
 - 2.2 In accordance with the invention, there is carried out an artificial "graceful degradation" whereby the reproduction signal is artificially altered in dependence on the quality of transmission or reception when there is a drop below a preset threshold value for the quality or quality factor of transmission or reception.
 - 2.3 Digital broadcast receiver, especially for (DAB)
3. Figure

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RECEIVING METHOD AND RECEIVER INCLUDING ARTIFICIAL	
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**RECEIVING METHOD AND RECEIVER INCLUDING ARTIFICIAL
RECEPTION QUALITY DETERIORATION AT BORDER OF
RECEPTION AREA**

5 In digital transmission media, for example
digital audio broadcasting (DAB), "DAB" is a trademark of
TELEFUNKEN Fernseh und Rundfunk [television and radio]
GmbH), the reception is suddenly broken off at the edge
of a propagation area, i.e. when the transmission channel
reaches the limit of its performance. This takes places
10 in particular when a powerful code is used for error
correction. The transition from a good reception to no
reception at all can take place here within a 1 dB
reduction in the reception voltage.

This behaviour is not desired since the user is
15 not prewarned in good time to switch over to another
transmitter. On the contrary, he will even incorrectly
assume that, when the reproduction fails, his receiver
has a fault or a defect, such as a faulty IC, loose
contact, loudspeaker failure or the like.

20 Although the problem of the failure to switch
over to another transmitter in good time can generally be
solved, for example with the aid of RDS, this is not the
case when there is a brief failure of reception such as
can occur when driving under bridges or the like.

25 Although the reception quality of VHF-FM is worse
at the edge of a propagation area of a transmitter, the
reception behaviour is significantly better since the
transition from very good reception to unsatisfactory
reception quality takes place in a range of the reception
30 voltage of up to 30 dB, that is to say smoothly from good
to bad even over relatively large distances.

On various occasions, it has been proposed to
achieve a so-called gradual degradation of reproduction -
also referred to as "graceful degradation" in digital
35 transmission systems. The forum report "Innovatives
Europa" [Innovative Europe], report [sic], Frank Müller-
Pämer: "Digital Audio Broadcast" (DAB), Bonn-Bad



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Godesberg, 8 March 1990 deals with the problem of preventing the DAB reception from breaking off abruptly when the reception field strength is diminishing and the reception conditions are being degraded by instead
5 switching over gradually from stereo to mono - similarly to VHF-FM. In the case of the switch-over from stereo to mono it can be assumed under unfavourable circumstances that the listener does not perceive the switch-over at all since the acoustic conditions are not always suitable
10 for this or because the transmission which is currently being received is being broadcast in mono in any case (for example news announcer).

Furthermore, the subject of "graceful degradation" of a digital audio transmission system is known
15 from J. Audio Engineering Reports Soc., Vol. 36, No. 1/2, 1988 January/February. In this publication, the advantage of "graceful degradation" is described for the case of audio reproduction when the audio signal is being transmitted over channels with a large bandwidth range.
20 However, measures indicated in this publication are not suitable for providing a solution of the problem described which is simple, cost-effective and always satisfactory to the listener, since, inter alia, the complexity of several error correction methods which are
25 effective in different ways is still considerable. It is also apparent that although the transmission region can be widened, this region however constitutes only little more than a few dBs.

Furthermore, since, in the case of digital links
30 and in particular in the case of mobile reception, the quality of the transmission link and of the reception very frequently changes to a pronounced extent, there is a highly fluctuating "graceful degradation" which does not correspond to the average behaviour of the transmission channel.
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The object of the invention is therefore to use simple means to avoid an abrupt breaking off of the reception or of the audio reproduction when the reception field strength is diminishing and the reception condi-

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tions are being degraded.

Moreover, the invention is based on the object of constructing a radio receiver in such a way that the aforementioned disadvantages do not occur during the
5 reception of digitally coded audio signals.

According to the invention, the object is achieved with a method for processing and reproducing digitally coded audio data, which method has the features according to Claim 1. Advantageous developments of the
10 method are described in the subclaims 2 to 6 and can be found in the following description.

The further object is achieved according to the invention with a radio receiver having the features according to Claim 7.

15 The invention is based on the following idea: the reception quality, for example the bit error rate, of the received audio data is to be measured with simple means, for example a bit error rate measuring device. The measured error rate, bit-error rate or reception quality
20 is a criterion for the transmission quality of the transmission channel or of the received audio data, for example the quality may be considered to be the reciprocal of the error rate. Moreover, a threshold value for the error rate (or transmission quality) is
25 specified, which threshold value is still below (above) the error rate (or quality) at which the abrupt breaking off of the reproduction or of the reception or of the transmission occurs.

When the value exceeds (is below) the specified
30 threshold value of the error rate (transmission quality), a change, which can be perceived well by the user, in at least one reproduction parameter or in the reproduction quality takes place. This may occur during the reproduction, for example in the form of an addition of
35 noise or an identifying tone to the audio reproduction signal or else of reduction in the reproduction loudspeaker level or displacement of the transmission limit frequency to low audible frequencies. The latter is achieved in that a digital low-pass filter is arranged



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and activated in the signal path of the audio signals to the reproduction device, the limit frequency or the limiting of the low-pass filter preferably decreasing in a variable or gradual way when the preset threshold value of the error rate is exceeded, and the reproduction frequency spectrum thus changing in a perceptible way. If the measured error rate lies below the threshold value, the low-pass filter does not have any changing influence on the reproduction.

Therefore, an artificial "graceful degradation" is carried out, the reproduction signal being artificially changed as a function of the transmission quality or reception quality when the transmission quality or reception quality is below a set threshold value.

By virtue of the simple measures described above, the user is made aware, in good time, of an expected abrupt breaking off of the reception. If, for example, a noise signal is added to the reproduction signal, the intended reproduction degradation corresponds to that to which a VHF-FM listener is accustomed in any case, such as the increased noise when driving under bridges, driving through tunnels or at the edge of a signal propagation area etc.

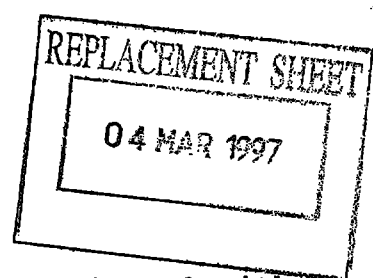
It is appropriate that the threshold value can be set in a variable way. This is advantageous in particular in the case of mobile radio reception when the threshold value is changed as the function of the travel speed since, at high speed, even an average error rate may still constitute a good level of reception quality or reproduction quality.

Preferably, the error rate or the derived quality criterion is subjected to low-pass filtering so that the artificial change at the reproduction device takes place more on the basis of the average channel quality. The low-pass filter here can also have different time constants for increase and/or decrease.

The invention is explained in greater detail below with reference to a possible exemplary embodiment.

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illustrated in the drawing.

The figure shows a DAB mobile receiver 1 with a reception antenna 2, an RF-IF section 3, which is connected thereto, an IF signal processor 4a, an A-D converter 4b which is integrated therein, a DAB source decoder 5, an audio-signal processor 6, an AF amplifier stage 7a with a D-A converter 7b contained therein, a loudspeaker 8 and a microprocessor 9 which contains a measuring device 9a (BER - Bit-ERROR-Rate) for determining the bit error rate of a digital signal system.

The DAB-specific digital signal processing is carried out, in accordance with the figure, by the IF signal processor 4a, DAB-source decoder 5 and audio-signal processor 6, these circuit elements being regularly constructed as large-scale integrated circuits. The audio-signal processor 6 performs the audio functions, such as influencing the tone, volume, cross-fader, balance etc, which are realised using analog circuit technology in contemporary receiver designs. The IF signal processor 4a serves to extract, from the signal which is supplied by the RF-IF section 3 designed using conventional technology, the data stream contained therein.

The microprocessor 9 serves to control the receiver, to which microprocessor 9 a value for the travel speed is fed via an input 10, the entire data stream or a part thereof is fed via an input 11, data from the source decoder is fed via an input 12 and input values from a control device (not vitro) are fed via further inputs 13 and 14. The microprocessor is connected to a control input 17 of the audio-signal processor 6 via an output 15 and a control line 16. Furthermore, the microprocessor contains a bit error rate measuring device 9a which determines the error rate of the received signals from the data stream fed via input 11. A threshold value for the error rate is stored in the microprocessor, the said threshold value being changed as a function of the travel speed. The current error rate or the threshold value, or a difference



between the two values, can be continuously indicated on a display.

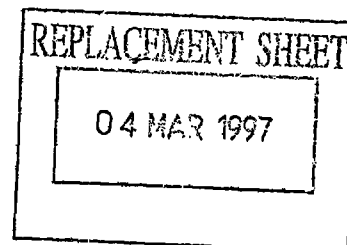
Depending on whether the measured error rate exceeds the threshold value of the error rate, the audio-signal processor is controlled in such a way that noise which can be perceived well by the listener is added to the AF signal to be amplified. If the reception breaks off abruptly, only noise or an identification signal (either continuously or occasionally), which is generated by the audio-signal processor, continues to be heard from the loudspeaker 8. The perceptible, artificial change in the audio signal increases gradually or incrementally, in each case depending on how far the threshold value of the error rate is exceeded. For this purpose, the measured value of the error rate is subjected in the micro-processor to low-pass filtering so that the artificial change takes place more on the basis of the average channel quality. The low-pass filter has different and/or variable time constants for increase and decrease. As the travel speed increases, the threshold value is changed, preferably increased.

Furthermore, various switch-overs of the RF-IF section 3 are carried out by the microprocessor 9 via a control line 18 as a function of the increase in the measured error rate. If the error rate suddenly jumps from a value below the set error rate threshold value (thus good reception) to a value far above the threshold value (abrupt breaking off of the reception), we [sic] described above, only a noise signal or identification signal is fed to the output of the signal processor.

However, if the increase in the error rate proceeds slowly and gradually up to the complete breaking off of the reception, a reception frequency with a transmitter, which is satisfactory for reception, of the same radio station, or of another radio station, is searched for in the microprocessor when the error rate threshold value is exceeded, and the RF-IF section 3 is retuned to the said reception frequency after the abrupt breaking off of reception. This ensures that even after

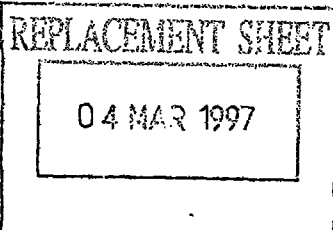


the breaking off of the reception, when data can no longer be received via other transmitters, the radio receiver automatically switches over to a transmitter which is suitable for reception, preferably transmitting the same radio station. A slow and gradual increase in the error rate is a sign that the receiver is leaving the propagation area of a transmitter, for example in the case of driving, a sudden increase in the error rate means that the vehicle is driving under a bridge or through a tunnel etc, the RF-IF section 3 remaining tuned to the same transmitter.



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Patent Claims

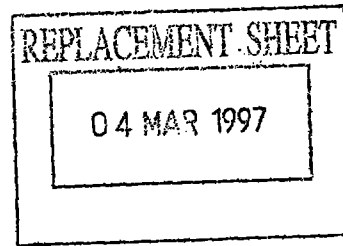
1. Method for processing and/or reproducing received, digitally coded audio data, for example digital audio broadcasting data (DAB), suitable means being used
5 to measure the reception quality or transmission quality, for example the bit error rate, of the audio data, a threshold value for the level of the reception quality or transmission quality being specified, and, when the said quality is below the threshold value, a change, which can
10 be perceived by the user, in a reproduction quality parameter taking place and/or a perceptible display being effected.
2. Method according to Claim 1, characterized in that, when the reception quality is below the specified
15 reception quality, a noise signal and/or identification signal, for example identification tone, is added to the reproduction signal.
3. Method according to Claim 1, characterized in that, when the reception quality is below the specified
20 reception quality, the reproduction signal is low-pass filtered and/or the volume level of the reproduction signal is reduced.
4. Method according to one of Claims 1 - 3, characterized in that the measured error rate is low-pass
25 filtered.
5. Method according to one of Claims 1 - 3, characterized in that, in the case of mobile reception, the threshold value for the reception quality or transmission quality is changed as a function of the
30 travel speed.
6. Method according to one of the preceding claims, characterized in that the level of the reception quality or transmission quality corresponds to the reciprocal of the error rate.
- 35 7. Radio receiver for receiving digitally coded audio broadcasting data (DAB), having a measuring device for measuring the reception quality, for example a bit error rate measuring device, a control device for controlling the reproduction of the audio broadcasting data,

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a reception/quality threshold value being specified in the control device and, when the reception quality is below the measured reception quality, the control device perceptibly changing the reproduction quality and/or the reproduction signals.

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RECEIVING METHOD AND RECEIVER INCLUDING ARTIFICIAL
RECEPTION QUALITY DETERIORATION AT BORDER OF
RECEPTION AREA

ABSTRACT

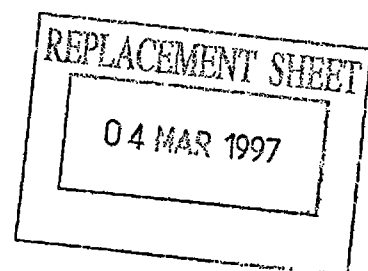
Method for the processing and reproduction of received digitally coded audio data and a radio broadcast receiver for the reception of digitally coded sound broadcasting data (DAB).

With digital transmission media e.g. digital sound broadcasting (DAB), there occurs an abrupt interruption of the reception at the edge of a coverage area i.e. when the transmission channel is at the limit of its capability. For digital transmission systems, the suggestion is repeatedly made of inducing a so-called sliding worsening of reproduction - "graceful degradation".

In accordance with the invention, there is carried out an artificial "graceful degradation" whereby the reproduction signal is artificially altered in dependence on the quality of transmission or reception when there is a drop below a preset threshold value for the quality or quality factor of transmission or reception.

Digital broadcast receiver, especially for (DAB)

FIGURE 1.





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PROCESS FOR PROCESSING AND REPRODUCING
DIGITALLY CODED AUDIO DATA AND RADIO RECEIVER
FOR DIGITAL AUDIO BROADCAST DATA (DAB)

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When using digital transmission media e.g. digital sound broadcasting (DAB, "DAB" is a trade mark of the TELEFUNKEN Fernseh und Rundfunk GmbH), there is an abrupt interruption in reception at the edge of a coverage area i.e. when the transmission channel is at the limit of its capabilities. This also happens, in particular, when a high performance code is being used for error correction purposes. A transition from a state of very good reception to a state in which there is no reception at all can thus occur when there is a reduction of just 1 dB in the received voltage.

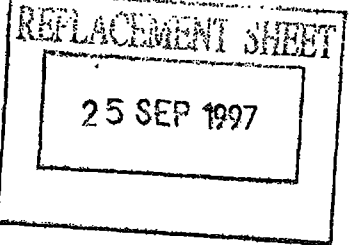
This type of behaviour is undesirable because the user is not warned in good time that he should switch to another transmitter. On the contrary, upon the cessation of reproduction, he might actually falsely assume that his receiving device is faulty or that it has become defective by virtue of e.g. a destroyed IC, loose contacts, a broken loud speaker or the like.

Generally of course, this problem of not switching over to another transmitter in good time can be resolved with the aid of RDS for example but this does not apply in the case of a short term failure in reception such as can happen when driving under bridges or suchlike things.

The reception quality of a VHF-FM transmission is of course poorer at the edge of a transmitter's coverage area but, in terms of reception behaviour, things are appreciably better since the transition from very good reception to impossible reception takes place over a range of received voltages of up to 30 dB i.e. smoothly from good to bad over much greater distances.

A radio broadcast receiver incorporating a circuit arrangement for identifying disturbances entailed by the location at which reception is occurring, wherein the radio broadcast receiver has an optical display device on which an indication is given as to whether the interference levels affecting reception quality are present on the inputs of the radio broadcast receiver, is known from DE-U-8 816 338.

In the case of digital transmission systems, the suggestion is repeatedly made of inducing a so-called sliding worsening of the reproduction - also known as "graceful degradation". This general problem of smoothly switching over from stereo to mono - in the same way as for a VHF-FM transmission - rather than of having an abrupt interruption of the DAB reception in the event of the received field strengths becoming weaker under worsening reception conditions is addressed in the Forum Report "Innovatives Europa", Report, Frank Müller-Römer: "Digital Audio



Broadcast (DAB), Bonn-Bad Godesberg, 8th March 1990. In adverse circumstances, one can assume that if there is a switch-over from stereo to mono, the listener will not even notice the change because the listening conditions are not always appropriate therefor or because the currently received transmission is in any case being transmitted in mono (e.g. a news broadcaster).

Moreover, the concept of "graceful degradation" of a digital audio transmission system is known from J. Audio Engineering Reports Soc., Vol 36, No 1/2, 1988 January/February. There, the advantage of "graceful degradation" is described for an audio reproduction system wherein the audio signal is transmitted over channels having a large range of bandwidth. However, the measures indicated there are not suitable for providing a simple, cost effective and, for the listener, a permanently satisfactory solution of the problem described since, amongst other things, the outlay is quite considerable when there are a plurality of error correcting methods that are effected in different ways. It has also been shown that although a broadening of the cross-over region can indeed be achieved, this only amounts to little more than a few dB.

Since, in addition, the quality of the transmission path or the quality of reception frequently changes by large amounts when using digital paths and especially in the case of mobile reception, there will be a large fluctuation in the "graceful degradation" that does not correspond to the average behaviour of the transmission channel.

The object of the invention is to avoid, using simple means, an abrupt interruption in reception or a break in audio reproduction in the event of received field strengths becoming weaker under worsening reception conditions.

Furthermore, the object of the invention is to construct a radio broadcast receiver such that the aforesaid disadvantages do not occur when receiving a digitally coded audio signal.

In accordance with the invention, the object is achieved by a method for the processing and reproduction of digitally coded audio data which has the features of claim 1. Advantageous developments of the method are specified in the appendant claims 2 to 6 and can also be gathered from the following description.

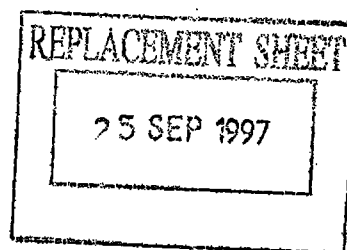
The further object of the invention is achieved, in accordance with the invention, by a radio broadcast receiver having the features of claim 7.

The invention is based upon the following considerations: One measures the reception quality e.g. the bit error rate, of the received audio data using suitable means e.g. a bit error rate measuring device. The measured error rate i.e. the bit error rate or reception quality is a criterion for the transmission quality factor of the transmission channel or that of the received audio data, the quality factor may, for example, be the reciprocal of the error rate. Furthermore, one defines a threshold value for the error rate (or transmission quality factor) which lies below (above) the error rate (or quality factor) at which the abrupt interruption in reproduction or the interruption in reception or transmission occurs.

Upon exceeding (falling below) the predetermined threshold value for the error rate (transmission quality factor), an alteration, which is readily perceptible by the user, is made to at least one of the reproduction parameters or in the quality of reproduction. This can happen during reproduction in the form, for example, of an addition of noise or of a characteristic tone to the audio signal being reproduced or else it can be achieved by a reduction in the volume level of the reproduced signal or by a displacement of the transmission limiting frequency to low audible frequencies. The latter is achieved in that a digital low pass filter is arranged in the signal path conveying the audio signals to the reproduction device and that the filter is activated whereby the limiting frequency or the limiting of the low pass filter is reduced, preferably, in a variable or smooth manner, when the previously set threshold value for the error rate is exceeded whereby the reproduction frequency spectrum is altered in a perceptible manner. If the measured error rate lies below the threshold value, the low pass filter does not have such a varying effect upon the reproduction process.

Thus, an artificial "graceful degradation" is produced wherein the signal being reproduced is artificially altered in dependence on the quality of transmission or reception when the quality drops below a preset threshold value for the quality or the quality factor of transmission or reception.

By means of the previously described simple measures, the user is made aware in good time of a forthcoming abrupt interruption in reception. For example, if a noise signal is added to the signal being reproduced, the intended worsening of reproduction will correspond to that which a listener is already used to in the case of VHF-FM reception, such as, for example, the increased noise when driving under bridges, when travelling through tunnels or at the edge of a signal propagation area, etc.



It is useful, to be able to set the threshold value in a variable manner. This is especially advantageous for mobile reception of radio broadcasts when the threshold value is altered in dependence on the speed of travel since even an average error rate can still mean good quality reception or a good quality of reproduction at high speed.

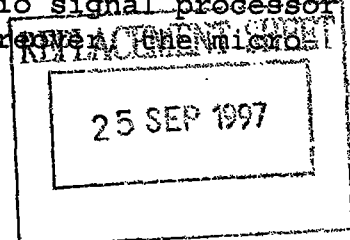
Preferably, the error rate or the quality factor criterion derived therefrom is subjected to a low pass filtering process so that the artificial alteration taking place in the reproduction device can occur more on the basis of the average channel quality. In this case, the low pass filter may also have different time constants in respect of a rise and/or fall.

The quality factor in respect of the quality of reception or quality of transmission may correspond to the reciprocal of the error rate.

The invention will be explained more fully hereinafter by means of one possible embodiment which is illustrated in the drawing. The Figure shows a DAB mobile receiver having a receiving antenna 2, a HF-IF section 3 connected therewith, an IF signal processor 4a, an A/D converter 4b integrated therein, a DAB source decoder 5, an audio signal processor 6, an AF amplifying stage 7a having a D/A converter 7b contained therein, a loud speaker 8 and a micro-processor 9 which contains a measuring device 9a (BER - Bit-ERROR-Rate) for the determination of the bit error rate of a digital signal.

In correspondence with the Figure, the digital signal processing specific to DAB is accomplished by the IF signal processor 4a, the DAB source decoder 5 and the audio signal processor 6 whereby these circuit sections are normally constructed as highly integrated circuits. The audio signal processor 6 takes over the audio functions such as tone control, volume control, mixing, balance etc., which are implemented in present day receivers using analogue circuit techniques. The IF signal processor 4a serves for extracting, from the signal which is delivered by the conventionally constructed HF/IF section 3, the data stream contained therein.

The micro-processor 9 is used for controlling the receiver, a value for the speed of travel being supplied to the micro-processor via an input 10, the whole data stream or a part thereof being supplied thereto via an input 11, data from the source decoder being supplied thereto via an input 12 and input values from a (not illustrated) control device being supplied thereto via further inputs 13 and 14. The micro-processor is connected to a control input 17 of the audio signal processor 6 via an output 15 and a control lead 16. Moreover, the micro-



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processor contains a bit error rate measuring device 9a which determines the error rate of the received signals from the data stream supplied via the input 11. A threshold value for the error rate, which is altered in dependence on the speed of travel, is stored in the micro-processor. The current error rate or the threshold value or the difference of the two values may be constantly indicated on a display.

In dependence upon whether the measured error rate exceeds the threshold value for the error rate, the audio signal processor is controlled in such a way that noise, which is easily perceptible by the listener, is added to the AF signal that is to be amplified. If the reception is abruptly interrupted, then only noise or a characteristic signal which is generated by the audio signal processor (either constantly or on an occasional basis) will be noticed from the loud speaker 8. The perceptible, artificial alteration of the audio signal increases smoothly or in step like manner, each time, in dependence upon the amount by which the threshold value for the error rate is exceeded. To this end, the measured value of the error rate is subjected to a low pass filtering process in the micro-processor so that the artificial alteration occurs more on the basis of the average channel quality. The low pass filter has different and/or variable time constants in respect of the rises and falls. The threshold value is altered, preferably raised, with increasing speed of travel.

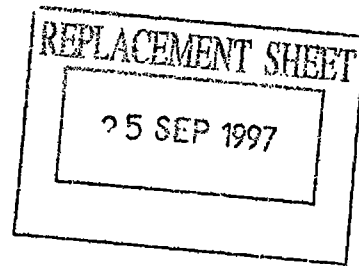
Moreover, in dependence upon the rise in the measured error rate, various changes are effected in the HF/IF section 3 by the micro-processor 9 via a control lead. If the error rate increases in a jumplike manner from a value below the set error rate threshold value (i.e. good reception) to a value far above the threshold value (abrupt interruption of the reception), then just noise or a characteristic signal will be provided at the outputs of the signal processor we [sic] previously described.

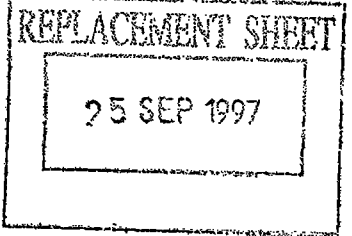
If, however, the increase in the error rate proceeds slowly and smoothly up to the point where there is a complete interruption in reception, then, upon the error rate threshold value being exceeded, a reception frequency of an acceptably receivable transmitter carrying the same or another programme and to which the HF/IF section 3 will be retuned after an abrupt break in reception, is sought by the micro-processor. It is ensured in this manner that, even after the break in reception and when data regarding another transmitter can no longer be received, the radio broadcast receiver will still switch automatically to an acceptably receivable transmitter and preferably to one carrying the same programme. A slow and smooth increase in the error rate is an indication that the coverage area of a transmitter is being left e.g. while driving, whereas a jumplike

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/increase in the error rate means that one is driving below a bridge or through tunnel etc, whereby the HF/IF section 3 will remain tuned to the same transmitter.





Claims

1. Method for the processing (6) and/or reproduction of received digitally coded audio data e.g. digital sound broadcasting data (DAB), characterised in that, the reception or transmission quality e.g. the bit error rate, of the audio data is determined by suitable means (9a), and that a threshold value for the quality factor in respect of the quality of reception or quality of transmission is used and, in the event that the detected reception or transmission quality falls below this threshold value, an alteration, which is acoustically perceptible by the user, will occur in at least one reproduction parameter or in the quality of the reproduction and/or an indication will be given that is acoustically perceptible by the user (6).
2. Method in accordance with Claim 1, characterised in that, upon the quality falling below the predefined reception or transmission quality, a noise signal and/or a characterising signal e.g. a characteristic tone is added to the signal being reproduced (6).
3. Method in accordance with Claim 1, characterised in that, upon the quality falling below the predefined reception or transmission quality, the signal being reproduced is low pass filtered (6) and/or the volume level of the signal being reproduced is reduced (6).
4. Method in accordance with any of the Claims 1 to 3, characterised in that, the measured error rate is low pass filtered.
5. Method in accordance with any of the Claims 1 to 4, characterised in that, for mobile reception, the threshold value for the reception or transmission quality is altered in dependence on the speed of travel.
6. Method in accordance with any of the Claims 1 to 6, characterised in that, the quality factor for the quality of reception or transmission corresponds to the reciprocal of the error rate.
7. Apparatus for the processing (6) and/or the reproduction of received, digitally coded audio data e.g. digital sound broadcasting data (DAB) characterised by:
 - a measuring device (9a) which detects the reception or transmission quality of the audio data e.g. the bit error rate (BER),



- a control device (9) for controlling (16) the processing (6) and/or the reproduction of the audio data, which device uses a threshold value for the reception or transmission quality and affects the processing (6) and/or the reproduction of the audio data if the detected quality of reception or transmission falls below this threshold value in such a way that an alteration, which is acoustically perceptible by the user, will occur in at least one reproduction parameter or in the quality of the reproduction.

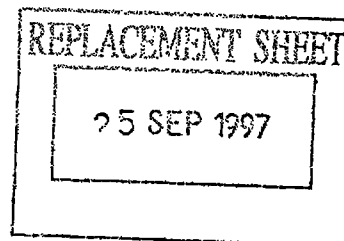
8. Apparatus in accordance with Claim 7, characterised in that upon the quality falling below the predefined reception or transmission quality, a noise signal and/or a characterising signal e.g. a characteristic tone is added to the signal being reproduced (6).

9. Apparatus in accordance with Claim 7, characterised in that, upon the quality falling below the predefined reception or transmission quality, the signal being reproduced is low pass filtered (6) and/or the volume level of the signal being reproduced is reduced (6).

10. Apparatus in accordance with any of the Claims 7 to 9, characterised in that, the measured error rate is low pass filtered.

11. Method in accordance with any of the Claims 1 to 6 wherein a receiving frequency for a transmitter that can be received properly and which is transmitting the same or another programme is determined in the case of a slow and creeping increase in the error rate when the threshold level is exceeded.

12. Method in accordance with Claim 11 wherein this receiving frequency is tuned in afresh following an abrupt break in reception.



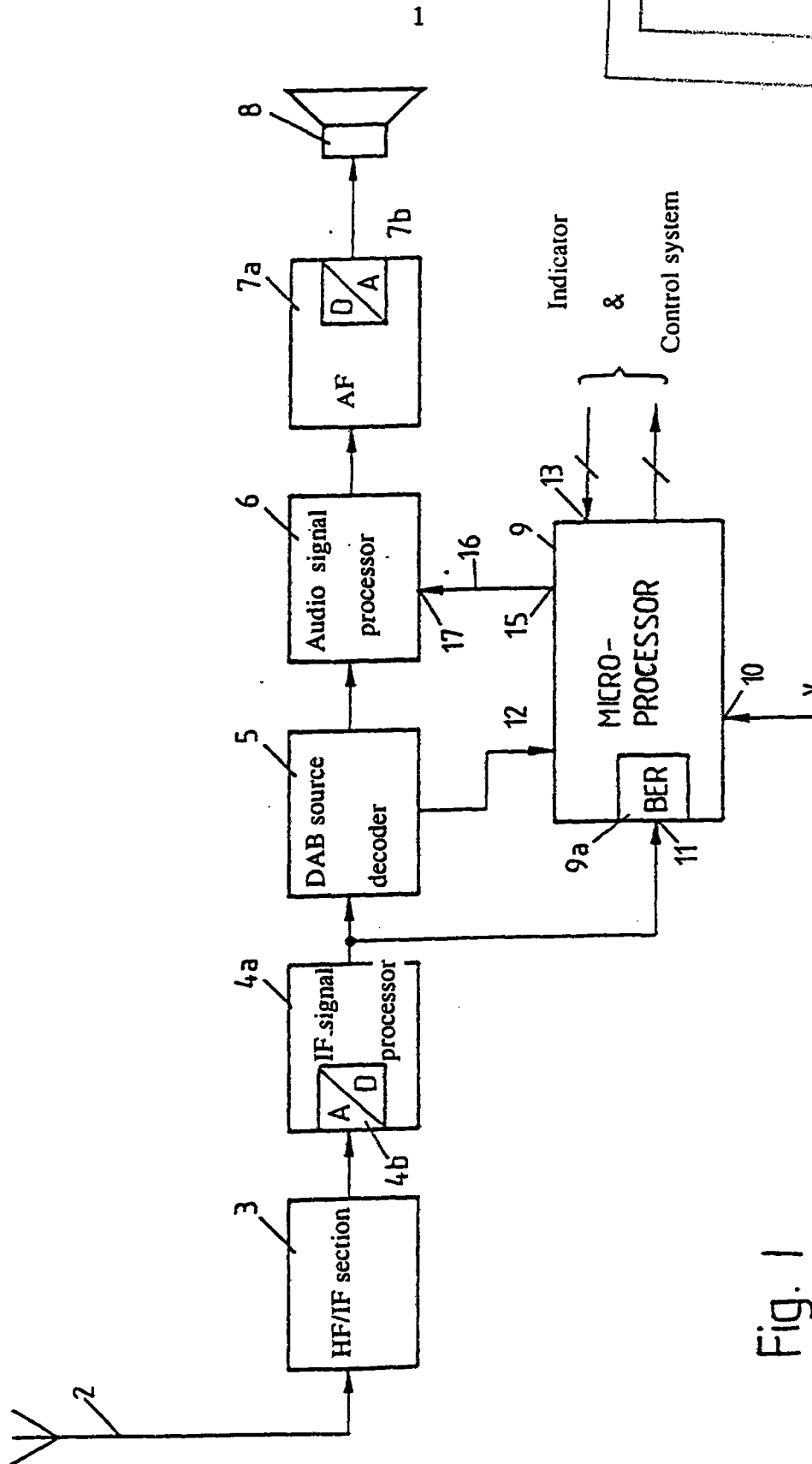
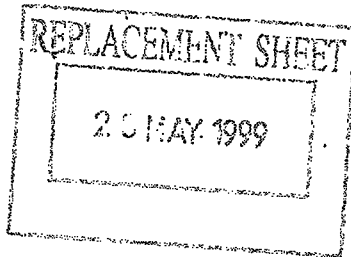


Fig. 1



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**PROCESS FOR PROCESSING AND REPRODUCING RECEIVED, DIGITALLY CODED
AUDIO DATA AND RADIO RECEIVER FOR DIGITAL AUDIO BROADCAST DATA (DAB)**

When using digital transmission media e.g. digital sound broadcasting (DAB, "DAB" is a trade mark of the TELEFUNKEN Fernseh und Rundfunk GmbH), there is an abrupt interruption in reception at the edge of a coverage area i.e. when the transmission channel is at the limit of its capabilities. This also happens, in particular, when a high performance code is being used for error correction purposes. A transition from a state of very good reception to a state in which there is no reception at all can thus occur when there is a reduction of just 1 dB in the received voltage.

This type of behaviour is undesirable because the user is not warned in good time that he should switch to another transmitter. On the contrary, upon the cessation of reproduction, he might actually falsely assume that his receiving device is faulty or that it has become defective by virtue of e.g. a destroyed IC, loose contacts, a broken loud speaker or the like.

Generally of course, this problem of not switching over to another transmitter in good time can be resolved with the aid of RDS for example but this does not apply in the case of a short term failure in reception such as can happen when driving under bridges or suchlike things.

The reception quality of a VHF-FM transmission is of course poorer at the edge of a transmitter's coverage area but, in terms of reception behaviour, things are appreciably better since the transition from very good reception to impossible reception takes place over a range of received voltages of up to 30 dB i.e. smoothly from good to bad over much greater distances.

A radio broadcast receiver incorporating a circuit arrangement for identifying disturbances entailed by the location at which reception is occurring, wherein the radio broadcast receiver has an optical display device on which an indication is given as to whether the interference levels affecting reception quality are present on the inputs of the radio broadcast receiver, is known from DE-U-8 816 338.

In the case of digital transmission systems, the suggestion is repeatedly made of inducing a so-called sliding worsening of the reproduction - also known as "graceful degradation". This

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processor via an input 10, the whole data stream or a part thereof being supplied thereto via an input 11, data from the source decoder being supplied thereto via an input 12 and input values from a (not illustrated) control device being supplied thereto via further inputs 13 and 14. The micro-processor is connected to a control input 17 of the audio signal processor 6 via an output 15 and a control lead 16. Moreover, the micro-processor contains a bit error rate measuring device 9a which determines the error rate of the received signals from the data stream supplied via the input 11. A threshold value for the error rate, which is altered in dependence on the speed of travel, is stored in the micro-processor. The current error rate or the threshold value or the difference of the two values may be constantly indicated on a display.

In dependence upon whether the measured error rate exceeds the threshold value for the error rate, the audio signal processor is controlled in such a way that noise, which is easily perceptible by the listener, is added to the AF signal that is to be amplified. If the reception is abruptly interrupted, then only noise or a characteristic signal which is generated by the audio signal processor (either constantly or on an occasional basis) will be noticed from the loud speaker 8. The perceptible, artificial alteration of the audio signal increases smoothly or in step like manner, each time, in dependence upon the amount by which the threshold value for the error rate is exceeded. To this end, the measured value of the error rate is subjected to a low pass filtering process in the micro-processor so that the artificial alteration occurs more on the basis of the average channel quality. The low pass filter has different and/or variable time constants in respect of the rises and falls. The threshold value is altered, preferably raised, with increasing speed of travel.

Moreover, in dependence upon the rise in the measured error rate, various changes are effected in the HF/IF section 3 by the micro-processor 9 via a control lead. If the error rate increases in a jumplike manner from a value below the set error rate threshold value (i.e. good reception) to a value far above the threshold value (abrupt interruption of the reception), then just noise or a characteristic signal will be provided at the outputs of the signal processor we [sic] previously described.

If, however, the increase in the error rate proceeds slowly and smoothly up to the point where there is a complete interruption in reception, then, upon the error rate threshold value being exceeded, a reception frequency of an acceptably receivable transmitter carrying the same or another programme and to which

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PROCESS FOR PROCESSING AND REPRODUCING RECEIVED, DIGITALLY CODED
AUDIO DATA AND RADIO RECEIVER FOR DIGITAL AUDIO BROADCAST DATA
(DAB)

ABSTRACT

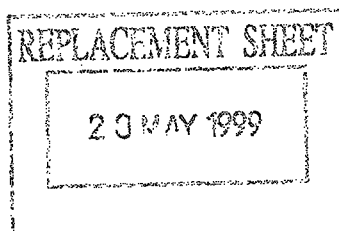
Method for the processing and reproduction of received digitally coded audio data and a radio broadcast receiver for the reception of digitally coded sound broadcasting data (DAB).

With digital transmission media e.g. digital sound broadcasting (DAB), there occurs an abrupt interruption of the reception at the edge of a coverage area i.e. when the transmission channel is at the limit of its capability. For digital transmission systems, the suggestion is repeatedly made of inducing a so-called sliding worsening of reproduction - "graceful degradation".

In accordance with the invention, there is carried out an artificial "graceful degradation" whereby the reproduction signal is artificially altered in dependence on the quality of transmission or reception when there is a drop below a preset threshold value for the quality or quality factor of transmission or reception.

Digital broadcast receiver, especially for (DAB)

FIGURE 1.



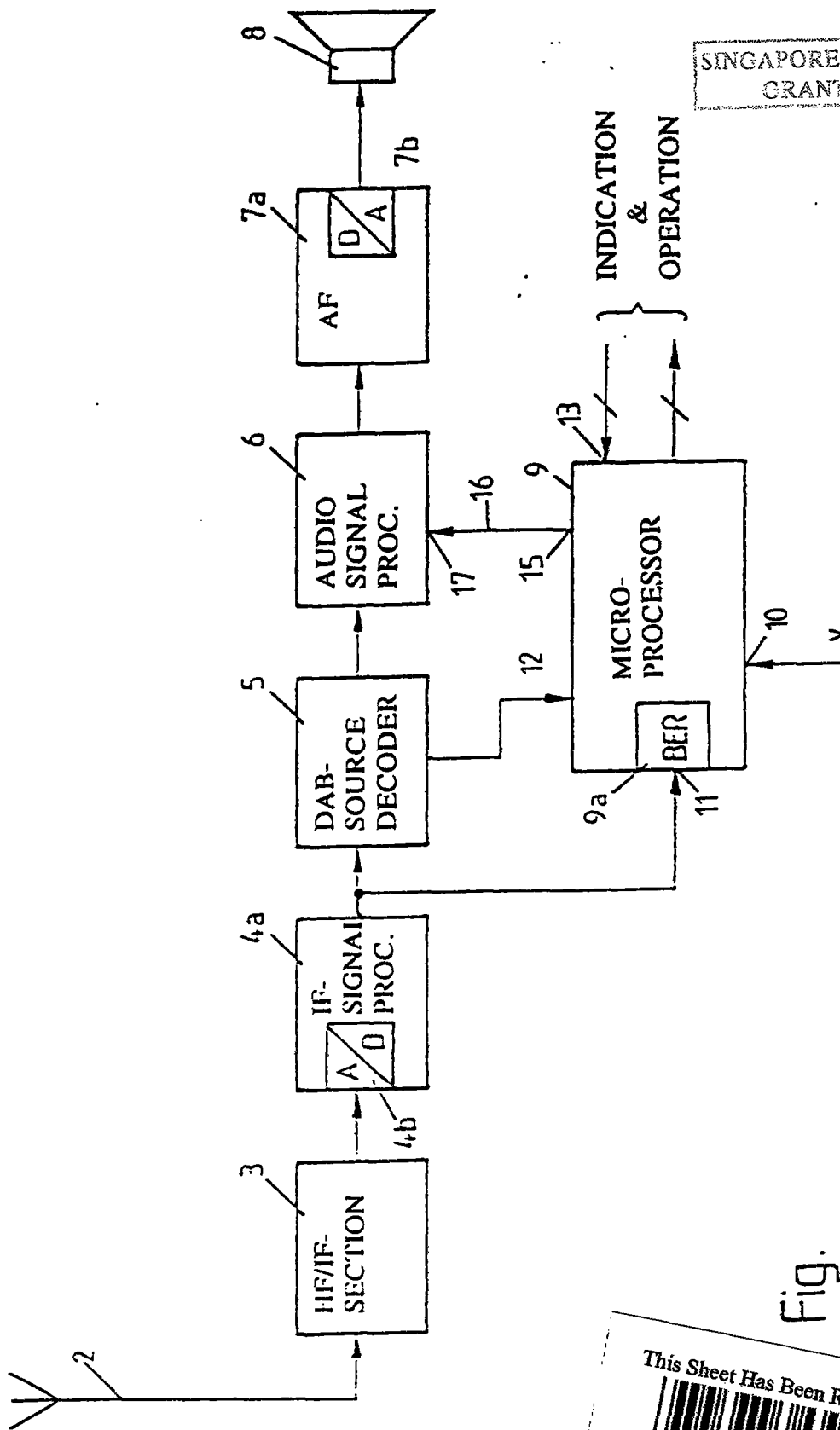
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Fig.

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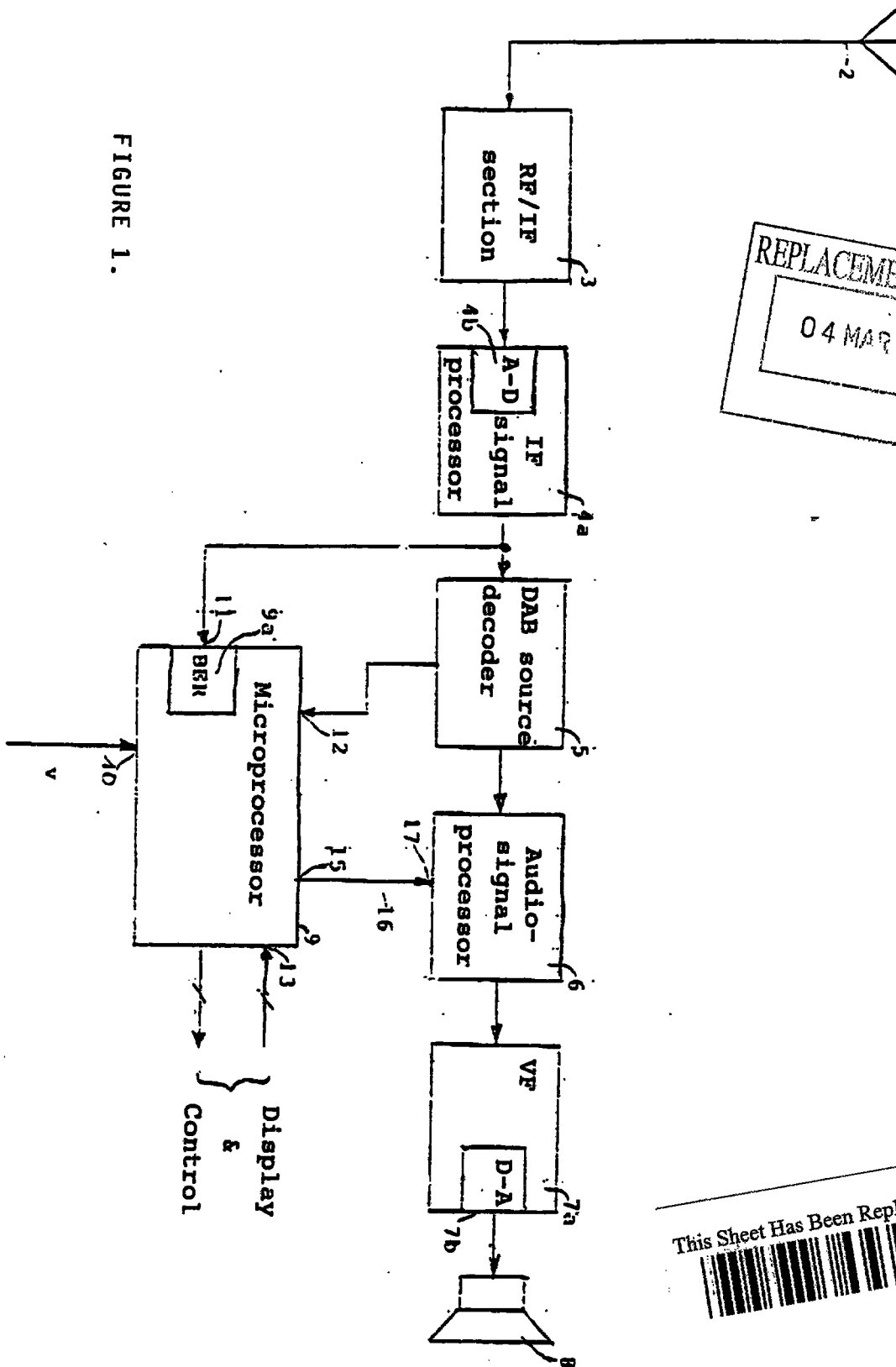


FIGURE 1.