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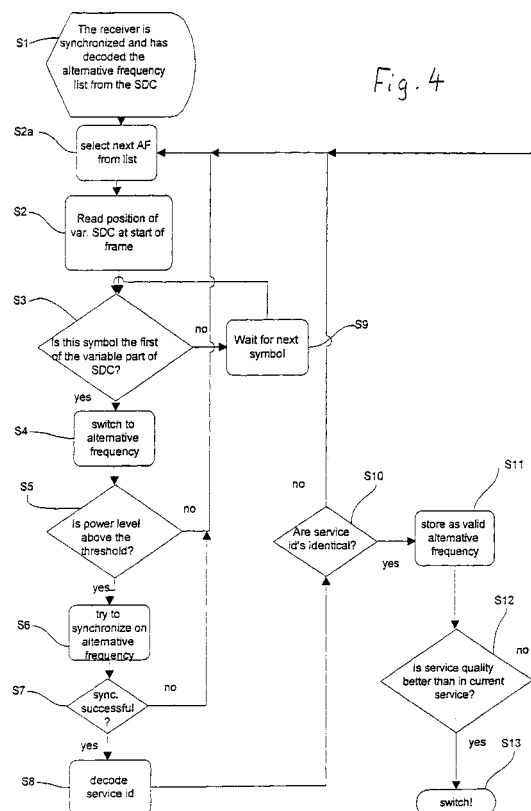
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(54) **Method and data frame structure for the digital transmission of information with quasi-seamless switch to an alternative frequency**

(57) For a digital transmission information system, in particular broadcast systems that deliver the same services in adjacent areas on different frequencies like DAB, video and data transmission in LF-, MF- or HF ranges, the invention proposes criterias to switch to alternative frequencies without loosing the service (seamless switch). The transmission system is defined such that the receiver is able to test the alternative frequencies without losing any relevant information on the current tuned frequency. The signal in the air consists of two parts, i.e. a continuous data-channel (SDC) like audio with interleaving in time but not repeated, and a static data-channel (SDC) including information about the service, multiplex configuration, program type, transmitter ID, service ID and alternative frequency list. During the static data-channel, the receiver has the time to check alternative frequencies without losing relevant information data.



EP 0 994 586 A1

Description

[0001] The invention relates to a method for the digital transmission of information in defined frames of information units, in particular digital audio, video and data broadcast via a plurality of transmitters delivering at least in part the same services in adjacent areas on different frequencies.

[0002] In public information service systems like DAB, DVB-T or digital LF-, MF- and HF broadcasting techniques for switching to alternative frequencies are used, but they provide no disturbance-free switching from one frequency to another. Document WO 97/40595 addresses the problem and describes a digital transmission process for transmitting information, in particular radio and/or television broadcasts by which information in different partial areas of a certain region is transmitted in transmission units with different frequencies. By synchronizing the transmission units of adjacent partial areas and matching the transmission units in those parts which contain the same information, it is possible to reduce interruptions during the reception of information caused for example when a mobile receiver moves from one partial area to another partial area. Even though a message interruption can be reduced in time if attention is paid to the matching of individual transmission units, e.g. radio programs, the said WO-document itself admits that a seamless switch from one frequency to another is not possible with this known digital transmission process.

[0003] It is an object of the present invention to provide a disturbance-free switching between various transmitters delivering the same services in adjacent areas on different frequencies.

[0004] The invention is based on the idea that it should be possible to allow a monitoring of alternative frequencies until a specific service identity code (ID) can be decoded without any loss of the relevant information signal, e.g. audio signal in the selected service. In other words, a proper criteria to switch to an alternative frequency without losing the service (seamless switch) should be designed such that the receiver is able to test the alternative frequency without losing any relevant information on the current tuned frequency.

[0005] Based on such observations as a first step, a method for the digital transmission according to the preamble of claim 1 and in accordance with the invention is characterized in that for achieving an at least quasi-seamless switch of a receiver from one to another alternative of said different frequencies, the defined information units frames are structured to consist of two frame parts, namely

- a continuous data-channel (CDC) as a first frame part, i.e. "pay-load information", and
- a static data-channel (SDC) as a second frame part including at least a start of frame indication and further information for the receiver to synchronize in

frequency and time to a certain data stream, wherein some of said further information consists of at least quasi-static symbols of which the structure is known to the receiver at the time of switching, and in that the receiver after evaluating the frame position of said quasi-static symbols is adapted to test an alternative frequency during the time when the quasi-static symbols of sequentially following frames are transmitted.

[0006] Further, advantageous embodiments and improvements of the above defined inventive concept are the subject of dependent claims.

[0007] A frame structure of a data stream for a digital transmission system comprising a plurality of transmitters delivering at least in part the same services is defined in claim 12 and provides in particular for that said static data-channel is adapted for transmission in time multiplex and comprises two parts, i.e. a first part located to come directly after or within a frame start symbol and including a transmitter ID, a service ID and information on the location within the frame of a second part of said static data-channel comprising static symbols or at least quasi-static symbols. If such a frame structure is used, during the static data-channel transmission, the receiver has the time to check alternative frequencies without losing relevant data and thus enabling a seamless switching to alternative frequencies.

[0008] The invention also relates to a receiver for digitally transmitted information which as to its hardware and software design is adapted to the method and the data frame structure processing as specified in the present disclosure of the invention.

[0009] The invention and the underlying concept will be described in the following with reference to the accompanying drawings in which

Fig. 1 depicts the principle frame structure of information units according to the invention;

Fig. 2 shows an example for a receiving condition for short wave frequencies in a certain area;

Fig. 3 elucidates the basic frame structure of a signal with its delayed version on an alternative frequency;

Fig. 4 depicts a flow chart for an alternative frequency switching in a receiver adapted for the method and information frame structure according to invention; and

Fig. 5 is a block diagram of a receiver with features according to the invention.

[0010] A digital transmission system embodying the invention should have a frame structure as shown in Fig. 1. The signal in the air shall consist of two parts, i.e.

- a continuous data-channel (CDC) like an audio-channel with interleaving in time but not repeated. and
- a static data-channel (SDC) comprising the information about the respective service, i.e., multiplex location, program type, alternative frequency (AF), transmitter ID, and as the case may be additional service information.

[0011] The static data-channel (SDC) should preferably satisfy the following rules:

- the SDC shall be transmitted in time multiplex;
- it may consist of several data symbols;
- it may consist of two parts, the first one has to come directly after or within a start of frame symbol and the second one may cyclically permute within the frame;
- if the SDC has two parts it should be either explicitly stated in the first part or implicitly by an algorithm, e.g. by frame and symbol counter in combination with a cyclical shift, at which instance or position the second part within the static data follows;
- in the latter case the rotation scheme of the second part of the static symbols must be known by the receiver;
- if a change in the data of the quasi-static part, e.g. a multiplex reconfiguration is provided, this has to be signalled in said quasi-static part in time and during several frames, so that the receiver can check its present quasi-static part for coming changes.

[0012] With a transmitted signal in the air following the above described frame structure it is possible for the receiver to test any possible alternative frequency during the time when the static data, i.e. the second part of the SDC is transmitted which is already known to the receiver and hence causes no loss of relevant information for the receiver.

[0013] Fig. 2 shows an example for a typical reception scenario. A receiver Rx gets the same service from two different transmitters Tx1 and Tx2 on two different frequencies f1 and f2. The two signals from Tx1 and Tx2 are transmitted time-synchronized, i.e. the same information is leaving the transmitters at the same time, or there is a determined time offset. If the receiver is tuned to the frequency f1 of transmitter Tx1, the signal of the alternative frequency f2 from transmitter Tx2 is late and if the receiver is tuned to Tx2 the signal from Tx1 is earlier.

[0014] In order to allow a switching without audible or visible interruption, in addition to the basic frame structure described above, the signals should fulfill the following requirements:

- the modulation and frame structure on both frequencies should be the same or should be known to the receiver, e.g., by link from DAB mode I to DAB

mode II or vice versa;

- a frame should always start with the frame Sync., Transmitter ID, Service ID, a frame counter from which the localisation of the variable part of the SDC could be derived for a given rotation scheme;
- the SDC should consist of a fixed part which, as mentioned above, indicating the frame start together with the service ID, and a second part with eventually flexible position inside the frame from frame to frame, however, determined, e.g. by referencing to a symbol counter;
- there is a rule how the second part, i.e., the flexible SDC symbols are located within the frame in time domain;
- the SDC is spread over the maximum expected delay inside the multiplex frame, e.g. the maximum delay between any two transmitters of the broadcasting network, e.g. TX1 and TX2;
- the signal to be processed in the receiver allows the receiver to synchronize to the respective other data stream and to decode its service ID within the time given by the length of the flexible second part of the SDC.

[0015] The checking of the alternative frequency works as shown by the block diagram of Fig. 5 and further explained by the flow chart of a respective algorithm of Fig. 4. The typical hardware structure of a digital receiver is shown in Fig. 5. The transmission signal in particular a digital audio broadcast signal is received by an antenna 1 and after amplification passes a selective pre-stage 2 and is supplied to a first input of a mixer 3 that receives at a second input thereof a frequency control signal supplied via an adaptable PLL circuit 4. The frequency supplied to the mixer 3 by the PLL circuit 4 is controlled by a circuit 13 for tuning the receiver as well as for the alternative frequency switching in accordance with the invention. Following an IF filter stage 5, the resulting signal is supplied to one input of a mixer 6 supplied at its other input thereof by a fixed frequency from a local oscillator 7. The resulting signal is again filtered in IF filter and automatic gain control (AGC) circuit 8 and is then A/D-converted in 9. The digital process in the lower part of the block diagram of Fig. 5 begins with an I/Q generation 10 followed for equalization and a fast Fourier transformation (FFT) 11. A demodulator circuit 12 is controlled by SDC data from circuit 13, the detailed function of which is explained further below with reference to Fig. 4. The demodulated signal then passes a Viterbi decoder (channel decoder) 14, and an audio decoder 15. Finally, following a respective power amplification the decoded audio data are supplied to a speaker or a pair of speakers 16.

[0016] The algorithm underlying the flow-chart of Fig. 4 and basically implemented in block 13 of Fig. 5 follows the subsequently explained sequence:

[0017] After the receiver is synchronized in step S1 and has decoded a respective alternative frequency list

from the SDC, at the frame start in step S2, the receiver evaluates the position (symbol number) of the second variable part of the quasi-static data in step S3 and continues with normal processing to step S4 if the evaluation result is positive; if "NO" the program goes to step S9 to wait for the next symbol. After complete reception of the last symbol before the variable part, the receiver switches to the next alternative frequency in its list in step S4. Then the power level is measured in step S5, and if it is above a reliable threshold the receiver continues with step S6 and tries to synchronize the alternative signal. As there is just one position where the variable second part of the SDC coincides with the frame start of the alternative frequency, this procedure in step S7 has to be repeated several times, in the worst case a number of times that correspond to the number of symbols per frame divided by a number of symbols of the second variable part of the SDC. If $\tau_{\max}$ is the maximum possible signal delay and t_d is the duration of one symbol and n_s is the number of symbols in the variable part of the SDC, the number of trials in the worst case is $2 \tau_{\max} / n_s t_d$. Finally, in step S8, the receiver checks during the right interval and tries to synchronize on the alternative signal and to decode the service ID. If it is the same service ID, the frequency tested in step S10 is stored as valid alternative frequency in step S11 and the procedure starts with the next frequency in the alternative frequency list. If the service IDs are not identical, the result is marked as an invalid alternative frequency for a certain period of time.

[0018] Fig. 3 shows the sequence of data symbols for the two signals for two different frames arriving at the receiver Rx. It is assumed in this case that the second flexible part of the SDC consists of two symbols and that this part moves cyclically by one symbol from frame to frame. When this part moves across the frame start the symbols N and 3 in Fig. 3 are used for three successive frames. In the first (upper) example the receiver Rx is tuned to the frequency f2 and has to check the frequency f1. In the second (lower) example the receiver can check the frequency f2 when it is tuned to the frequency f1.

[0019] In Fig. 3 the following abbreviations are used:

Sid =	Service ID
Txid =	Transmitter ID
sdcl oc =	A static data location of 2 nd part of SDC
FS =	Start of Frame Synchronization

[0020] The suggested frame structure according to the invention allows the receiver to check the quality of alternative frequencies without losing relevant data of its present main service reception, i.e., seamless switch between alternative frequencies of various transmitters delivering the same service is possible. The receiver checks the alternative frequency during the SDC period of respective frames. The delay between different signals can be detected by the method according to the invention with an accuracy of at least one symbol period,

and this information can be used for hyperbolic navigation if at least three alternative frequencies can be received in a present receiver position. If on the other hand the location of the transmitters, the location of the receiver (e.g. by means of GPS) and the static delay between the transmitter signals is known by the receiver, it can calculate exactly the time difference which the various signals have at the location of the receiver which is the relative path distance of the transmitters and the receiver divided by the speed of light plus the static delay. By dividing this delay by the symbol duration, the receiver knows exactly at which symbol it has to switch to the alternative frequency if there is currently the SDC. This saves processing time. The exact knowledge of the valid alternative frequency, however, is a prerequisite for a seamless switch during bad reception conditions.

Claims

1. A method for the digital transmission of information in defined frames of information units via a plurality of transmitters delivering at least in part the same services in adjacent areas on different frequencies, **characterized in that** for achieving an at least quasi-seamless switch of a receiver from one to another alternative of said different frequencies, said defined information units frames are structured to consist of two frame parts, i.e.,
 - a continuous data-channel (CDC) as a first frame part, and
 - a static data-channel (SDC) as a second frame part including at least a start of frame indication and further information for the receiver to synchronize in frequency and time to a certain data stream, wherein some of said further information consists of at least quasi-static symbols of which the rotation scheme within a frame is known to the receiver at the time of switching, and in that the receiver after evaluating the frame position of said quasi-static symbols is adapted to test an alternative frequency during the time when the quasi-static symbols of sequentially following frames are transmitted.
2. The method of claim 1, **characterized in that** said same services are transmitted time-synchronized by said plurality of transmitters and with the same modulation scheme.
3. The method of claim 1, **characterized in that** said same services are transmitted by said plurality of transmitters with a determined time offset known or signalled to the receiver and with the same modulation scheme.
4. The method of at least one of the preceding claims,

characterized in that said static data-channel (SDC) is transmitted in time multiplex.

5. The method of at least one of the preceding claims, **characterized in that** said static data-channel (SDC) is composed of two parts of which the first part is positioned directly after or within a start of frame indication and the second part comprising said at least quasi-static symbols is adapted to cyclically permute within the frame, and in that said first part comprises said further information including at least a transmitter ID, a service ID and information for the receiver to locate the position of said second part within a respective frame structure. 5
6. The method of claim 5, **characterized in that** said information for the receiver to locate the position of said second part is comprised in a specific data block. 10
7. The method of claims 5, **characterized in that** said information for the receiver to locate the position of said second part is an initializing command for a predefined algorithm subroutine. 15
8. The method according to any one of the preceding claims, **characterized in that** said defined frames of information units are units of digital audio-, video- and data broadcasts. 20
9. The method according to claim 8, **characterized in that** said broadcasts are LF-, MF- or HF broadcast transmissions. 25
10. The method of claim 5, **characterized in that** for preparing a seamless alternative frequency switching the receiver is adapted to follow the program steps of 30
 - (a) reading a decoded and/or stored alternative frequency for the current service ID of said static data-channel, 35
 - (b) reading or evaluating the position of said quasi-static symbols in said second part of said static data-channel and determine the first symbol thereof, 40
 - (c) switching to said alternative frequency during the time slot of said quasi-static symbols period and checking the power level of said alternative transmitter against a minimum level, 45
 - (c1) repeating steps (b), and (c) if the power level is below minimum or if above minimum 50
 - (d) trying to synchronize to said alternative frequency and if not successful 55

-- (d1) repeating steps (b) to (d), or if successful

(e) decoding the service ID, comparing the decoded result for identity against the present service ID, and if not identical

-- (e1) repeating steps (b) to (e), or if identical

(f) storing alternative frequency as valid, then
(g) switching to a decoded next alternative frequency and repeating all previous steps.

11. The method of at least one of the preceding claims **characterized in that** the static data-channel (SDC) is at least spread over the maximum expected delay between any of two alternative transmitters (Tx1, Tx2).

12. Frame structure of a data stream for a digital transmission system comprising a plurality of transmitters delivering at least in part the same services, **characterized in that** each data frame consists of

- a continuous (pay-load) data-channel (CDC) as a first frame, and
- a static data-channel (SDC) as a second part, said static data-channel being adapted for transmission in time multiplex and comprising two parts, i.e.
 - a first part located to come directly after or within a frame start symbol and including a transmitter ID, a service ID and information on the location within the frame of
 - a second part of at least quasi-static symbols.

13. A receiver for digitally transmitted information adapted to the method and/or data frame structure processing as defined in at least one of the preceding claims.

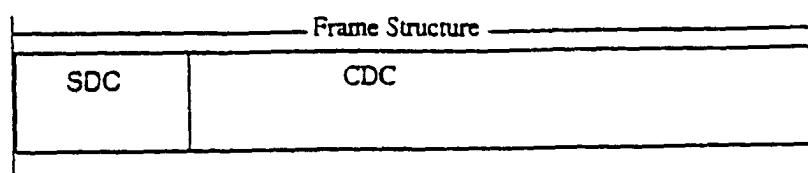


Fig. 1

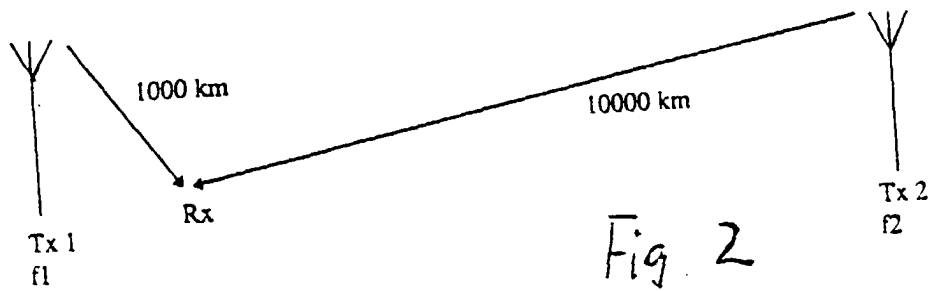
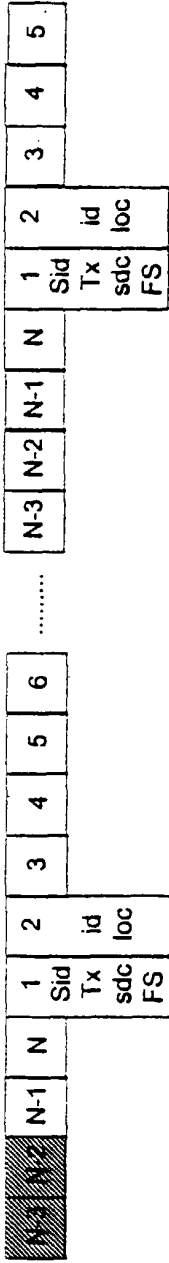
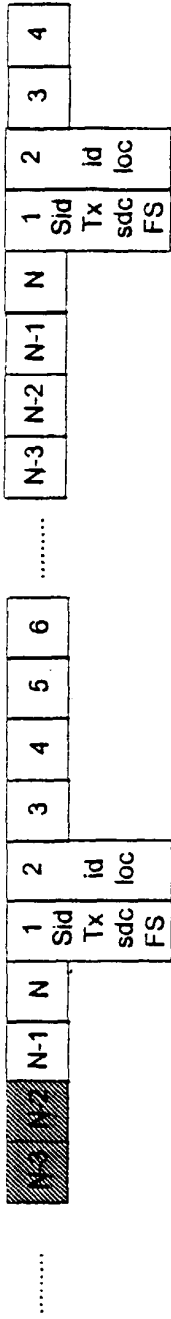


Fig. 2

Frame m-8
Signal from Transmitter Tx 1

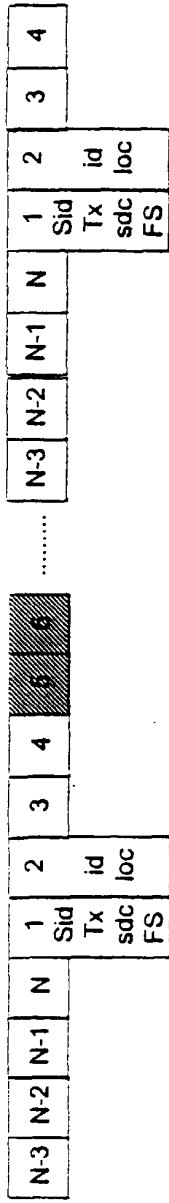


Signal from Transmitter 2

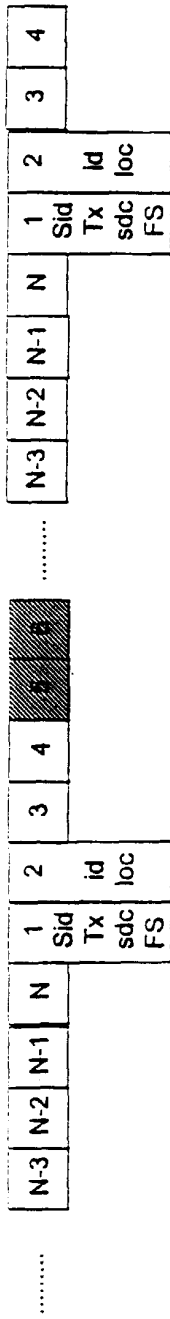


A receiver tuned on f2 can check and find Sid at f1

Frame m
Signal from Transmitter 1

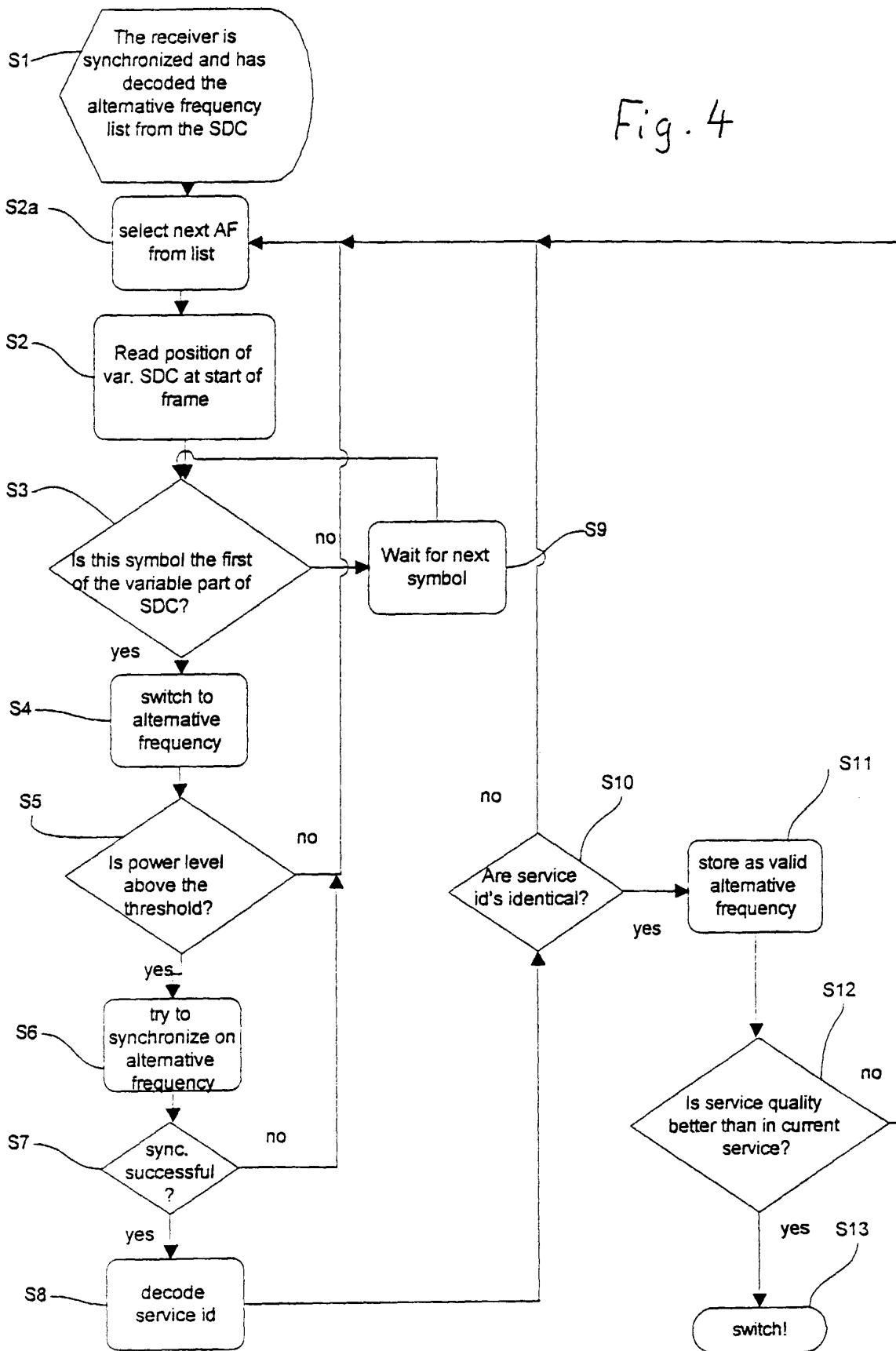


Signal from Transmitter Tx 2



A receiver tuned on f1 can check and find Sid at f2

Fig. 4



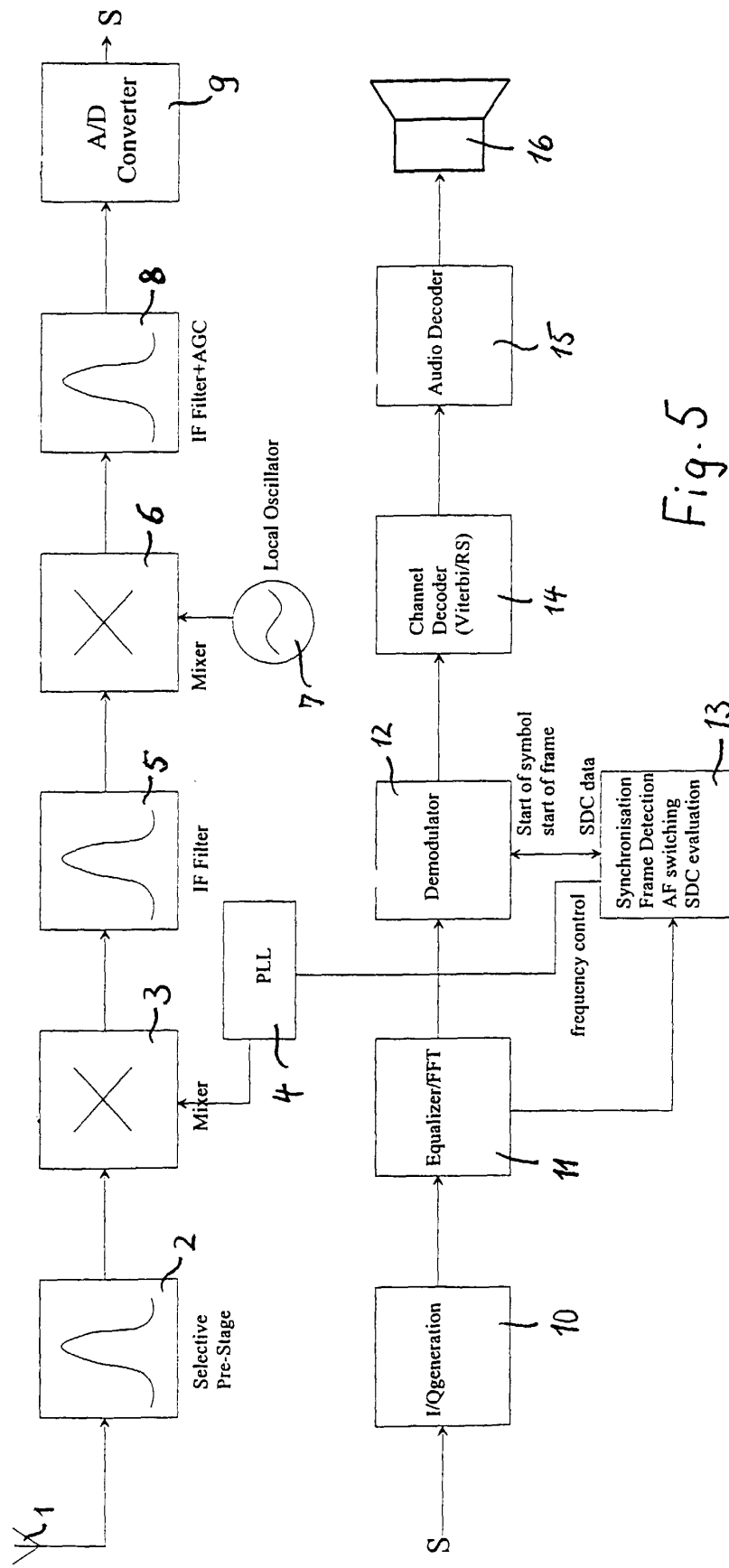


Fig. 5



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Application Number
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
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Place of search		Date of completion of the search	Examiner
THE HAGUE		9 March 1999	Simon, V
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